Morphological study, microscopical study of powder and elemental analysis of *Phyla nodiflora* (L.) Greene.

Aung Myint Thein¹

Abstract

Kalay University is situated on the border of Sagaing Region and Chin State. This area is gifted with diverse and unique flora. *Phyla nodiflora* (L.) Greene. is a valuable medicinal plant. This plant can be used for various purposes. It is needed to know the right and exact scientific name, constituents, and microscopical characters because these are very important for the medicinal plants as well as the genuine medicine. The present research paper is conducted during June 2009 to May 2013. During field survey, questions were used to interview the local inhabitants, older people who were familiar with the uses of this plant, and tested the patients of local people. The collected plant specimens were identified and expressed its Botanical name, English name, Myanmar name, local name, the family it’s belong to, the flowering and fruiting periods, literature uses and medicinal folk recipes, and traditional use. The illustrations for this species includes the natural habit, flowers, and fruits are given. The dried specimens were pulverized and then elemental analysis was done. The data of elemental analysis are precisely presented. The microscopical characters of powder were also mentioned.

Introduction

Plants are an essential component and benefactor of animals. Medicinal plants have been used since prehistoric period to cure the various diseases. Traditional medicine is generally transmitted through a community, family and individuals. Results of various experimentations many medicinal plants were used as a source of important medicines. Some ornamental or other plants of relatively recent introduction for curative uses have been invented without any historical basis. Plants, especially angiosperms are the original source of most plant medicines. Major pharmaceutical companies are currently conducting extensive research on plant materials for their potential medicinal value. Nowadays, many scientists surveyed on useful medicinal plants from their countries to obtain new drugs for chemotherapy.

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Metals generally regarded as essential for human health in trace amounts include iron, zinc, copper, manganese, chromium, molybdenum and selenium. They are essential because they form an integral part of one or more enzymes involved in a metabolic or biochemical process. The primary role of such elements is a catalyst, and only trace amount are necessary for cellular function (Anonymous 2012).

Although minerals comprise only a fraction of total body weight, they are crucial for many body functions including transporting oxygen, normalizing the nervous system and simulating growth, maintenance and repair of tissues and bones. There are actually 60 minerals, 15 vitamins, 12 essential amino acids and 3 essential fatty acids that your body needs every day. Too much of one element can lead to imbalances in others, resulting in disease rather than the absence of disease.

The relationship of minerals to human health that keeping the level of minerals in balance in every tissue, fluid, cell and organ, in the human body may be the key to maintaining human health (Alexander 2012).

Daily intake of nutrients as performing dual roles are first in the role of preventing mineral deficiencies and second in optimizing the disease-preventing properties of these nutrients. The key is insuring that the body always receives an adequate and balanced supply of all minerals (elements) that might be of potential benefit to maintaining health or restoring health. The health benefits of some trace elements are in balance with other elements they interact with (Alexander 2012).

There are thought to be 300 – 315 thousand species of plants, of which the great majority, some 260 – 290 thousand, are seed plants. Plants serve as ornaments and until recently and in great variety, they have served as the source of most of medicines and drugs.

A medicinal plant is nay plant which in one or more or its organ, contains substances that can be used for therapeutic purposes or which is a precursor for synthesis of useful drugs (Trease and Evans 1978).

The description of powdered drugs must be approached to provide characters which can be used for their rapid identification. The crude drugs are various forms. Each drug substance has shape, size; colour, odour and taste are variations (Wallis 1967).
The properties of the *Phyla nodiflora* are bitter, anodyne, antibacterial, carminative, deobstruent, diuretic, emmenagogue, parasiticide and refrigerant, and considered analgesic, anti-inflammatory, antioxidant, nociceptive, antimicrobial, antipyretic, antitumor, lipid peroxide scavenging and free radical scavenging (Anonymous 2012).

In Siddha Medicine & Natural Treatment, the properties of this plant are expectorant, tonic, demulcent and astringent (www.networkedblogs.com/blog/siddhamedicine_medicine).

*Phyla nodiflora* is used for natural cure for dandruff, piles, leucorrhoea, ulcers (Anonymous 2000–2011). *Phyla nodiflora* is also used suppurations, cold, lithiasis (http://en.wikipedia.org/wiki/Phyla_nodiflora).

*Phyla nodiflora* is used as astringent, dandruff, demulcent, and expectorant (Anonymous 2010).

In Philippines and India, the plant decoction is taken as a diuretic. In India, toasted used in infusion for indigestion in children. Also used as a demulcent in gonorrhea. In Sri Lanka, leaves are eaten. In Philippines, leaf infusion taken as a tea. Plant has cooling, diuretic, and febrifuge properties. An infusion of leaves and tender stalks are given to women after delivery and to children with indigestion. Plan used as a demulcent in cases of gonorrhea. A paste of the plant is applied as a suppurant for boils, chronic indolent ulcers, and swollen neck glands. In Bahrain, dry leaves infusion as a febrifuge, diuretic, astringent, for dysuria, diarrhea (Anonymous 2008).

In the Philippines, fresh leaves used as tea substitute; hence referred to as “chachahan”. Infusion of leaves and tops are used as carminative and diuretic. In India, plant is used as demulcent in gonorrhea. Also, paste of leaves applied to swellings and wounds. Toasted tender stalks and leaves, in fusion, used for children’s indigestion. Juice of roots used for gastric problems. Used as by women after childbirth. Hindus used it for fever and as diuretic and applied as paste to promote suppuration. Infusion used in colds with fever; also as diuretic and for lithiasis. Poultice of fresh plant used to hasten ripening of boils. Used for asthma, bronchitis, diseases of the heart, blood, and eyes. Paste or poultice of *Phyla nodiflora* plant applied to swollen cervical glands, erysipelas and to chronic indolent ulcers (Anonymous 2012, http://www.stuartxchange.com/Busbusi.html).

The dried powder of the leaves along with jeerakam is ground well and given in the dosed of 5 to 10 grams daily for Leucorrhoea. The chuntney prepared with
leaves is effective in curing piles. The external application prepared from paste of leaves is helpful in the ripening of ulcers and pustules. The leaves are used as a paste and applied in the scalp for dandruff. A Siddha preparation called Poduthalai thylam is very effective anti-dandruff medicine (Anonymous 2012).

The Verbenaceae are predominantly a tropical or subtropical family. The family is composed of about 98 genera and 2614 or more species. A number of genera contain important ornamentals (Lawrence 1964).

*Phyla nodiflora* (frog fruit) is an ornamental plant in the Verbenaceae family, and is native to South America and the United States. It can be found in tropical areas around the globe, a naturalized species in many places. It is often grown as groundcover, and is sometimes present in yards as a lawn weed (Pink 2004).

The present study is concerned the morphological study, microscopical study of powder form, and investigation of elemental role in a Myanmar Traditional Medicine of *Phyla nodiflora* which is generally claimed to be effective in ureterolithiasis.

Kalay University is situated on the border of Sagaing Region and Chin State. The area is gifted with diverse and unique flora. Valuable medicinal plants are found abundantly in Myanmar.

At the present, the Government of Myanmar has assumed a vital role in the development of traditional medicine system. The Government of Myanmar has urges research personnel to enhance the quality and promote the systematic development of traditional medicine which is of the paramount importance, it includes: to sustain and properly preserve the effective and potent herbs, to conduct biomedical research for the scientific development of traditional medicine, to further upgrade and conduct extensive research on traditional drugs which can be used against certain diseases that can not be cured by western medicine, to apply scientific research by using modern methods and equipment for extraction and preparation of affordable traditional drugs, having fewer side effects than western medicine in order to make it safer and more reliable for the people (Editorial 2000).

The aim and objectives of the present study are to identify and classify the plant, to advance the research level of natural plant product, to sustain and properly preserve the effective and potent herbs, to conduct biochemical research for the scientific development of traditional medicine, and to conduct extensive research on
traditional drugs which can be used against certain diseases that cannot be cured by Western medicine.

**Materials and Methods**

The plant specimens were collected during the flowering and fruiting period from Kalay University Campus in the year 2009 and 2012 for identification, microscopical study and elemental analysis. These plants are distributed in wild. The flowering and fruiting occurred from May to October. The fresh specimens are photographed in natural habitats for visual records of its community as well as its morphology. After collection the fresh specimens are identified by using literature references such as Lawrence (1969), and Anonymous (2009).

For the preparation of powdered sample, the fresh specimen were cleared and dried in shade for several days. After the plant parts were completely dried, the dried plants were pulverized by grinding with mortar and pestle and then sieved. The powder was packed in tightly closed bottle and stored at room temperature to prevent moisture changes and contaminations for the elemental analysis, and for the study of diagnostic characters and microscopical characters.

The microscopical characters of *Phyla nodiflora* powder was examined and determined by Esau (1965), Metcalfe and Chalk (1979), and Pandey (1996).

Elemental determination for the experimental methods used in this work was done by “Spectro xepos” spectrometer system in Physic Department, Mandalay University.

**Results**

Morphological study
Botanical Name: *Phyla nodiflora* (L.) Greene (Figure 1)
Synonym : *Verbena nodiflora* L.; *Lippia nodiflora* A. Rich
Myanmar Name: Pa zun tha bet
Local Name : Kyauk kwe pin
English Name : Frog fruit, Cape weed, Creeping Lip Plant, Frog’s Bit, Licorice, Verbena, Turkey Tangle Frog fruit
Family : Verbenaceae
Morphological characters
Prostrate, mat-forming perennial herbs, creeping, much branched, new branches sometimes semi-erect, 15.0 – 30.0 cm height. Roots are prostrate, creeping, rooting at nodes, much branched; adventitious roots from nodes. Stems are solid, terete, young stem more or less quadrangular, herbaceous, green; nodes swollen above the joint, internodes 1.8 – 8.0 cm long. Leaves are opposite and decussate, simple, exstipulate; petioles subsessile, straight; lamina spatulate, obovate to oblanceolate, about 1.5 – 4.0 cm long and 0.5 – 1.7 cm wide, distally serrate and proximally one third to two third entire, apex obtuse, acute with a minute mucro, base narrowly cuneate; dorsiventral, green, above glabrous and below hairy; unicostate and reticulate venation. Inflorescence is generally one, rare two, compact spike with numerous flowers, spikes cylindric to ovoid, 0.5 – 2.8 long and 0.4 – 0.8 cm wide. Peduncles are 1.0 – 6.0 cm long. Flowers are very small, white or pink or purple in dense spikes on axillary peduncles, bisexual, zygomorphic, pentamerous, hypogynous. Calyx 4 sepals, small, two lobes, each two-toothed, synsepalous, valvate, and persistent. Corolla 5 petals, synpetalous, bilabiate, anterior lip three lobed, median largest; posterior lip shortly two lobed; pinkish purple or white; tubular; imbricate. Stamens are four, didynamous; petalostamenous, anther dithecous, introrse, dorsifixed, longitudinal dehiscence. Carpels are two, syncarpous; two locules, axile placentation, one ovule in each locule, style terminal and small, inserted, stigma obliquely capitates. Fruit is dry capsule. Seed testa is thin, embryo straight, two equal and thick cotyledons.

Flowering and fruiting time - June to October
Specimen examined - Kalay University Campus; August 6, 2009 and 2012; Aung Myint Thein

Elemental analysis of *Phyla nodiflora* (L.) Greene.

The experimental work for the analysis of elemental concentrations was carried out at the Physic Department, Mandalay University. The experimental data are shown in Figure (2 & 3); according to this calcium, potassium and chlorine are the major elements, and chromium, manganese, iron, copper and zinc are essential metals for human health, and phosphorus, sulfur, potassium, calcium, chromium, iron, cobalt, copper, zinc, selenium, molybdenum, and iodine are examples of health benefits of selected trace elements, and aluminum, arsenic, cadmium, mercury and lead are toxic elements and less content except aluminum.

Microscopical study on powder form of *Phyla nodiflora* (L.) Greene.
The powder sample was examined under the electronic microscope in Botany Department, Kalay University. The microscopical characters are shown in figure (4). The sensory characters of *Phyla nodiflora* powder are brownish yellow colour, slightly aromatic odour, bitter taste and granular fibres texture.

Figure 1 *Phyla nodiflora* (L.) Greene.

A, Habitat; B, Rooting; C & D, Inflorescence; E, Fruit
Figure 2 Determination of relative compositions of elements in the whole plant powder of *Phyla nodiflora* by EDXRF spectrometry.
Figure 3 Determination of relative compositions of elements in the whole plant powder of *Phyla nodiflora* by EDXRF spectrometry.
Figure 4 Microscopical characters of *Phyla nodiflora* (L.) Greene.

A, Unicellular two-armed trichome with fragment of vessel; B, Fragment of epidermis; C, Fragment of epidermis with stoma; D, A single stoma with two guard cells; E-H, Macrosclereids; I&J, Scalariform vessel; K, End of helically thickened vessel showing scalariform perforation plate; L, Scalariform vessel with sieve tube; M, Scalariform and helical vessel with sieve tube; N, Sieve tube showing an oblique sieve plate; O, Helically thickened elements have a few interconnections among the coil of helix; P, Collenchyma; Q, Tracheidal fibres; and R, wood fibres.
Discussion and Conclusion

*Phyla nodiflora* is a flowering and broadleaf plant. It grows in a groundcover or turf like manner and is often present in yards as a lawn weed. The inflorescence consists of a purple-colored centre encircled by small white to pink flowers. It grows along stream banks and in grassy places.

The fresh leaves are used as a tea substitute. It is a good ground cover for dry sunny banks. This plant can be used as a grass substitute for lawns in tropical areas.

Herb, exstipulate, opposite leaves, spathulate, serrate, cuneate; spikes cylindric; flowers zygomorphic, hypogynous; sepal small, synsepalous; corolla bilabiate; stamens didynamous, petalostamenous; anther ditecous; carpels 2, one ovule in each locule; stigma capitates; fruit break, characters are agreed with Lawrence (1964) and Anonymous (2009) (Figure 1).

According to elemental analysis, it contains health benefits trace elements and essential metals for human health (Figure 2).

Metals play a major role in nutrition, since our body, like all living organisms, needs daily intakes of many metals such as zinc, copper and manganese. Lead screens are essential to protect us from X-rays and on a more daily basis, from the radiation of our televisions and computers (Anonymous 2012).

There is a significant body of evidence that minerals by themselves and in proper balance to one another have important biochemical and nutritional functions. Minerals may play a significant role against a variety degenerative diseases and processes. They may also prevent and reduce injury from environmental pollutants and enhance the ability to work and learn. They can also protect the body from the effects of toxic minerals (Alexander 2012).

The price of the effective medicinal plant resources are becoming high and some parts of the medicinal plants were substituted by other plant parts as adulterants which have not contain the medicinal properties. Moreover, most of the tablet of traditional medicines are made from plant powder and then there were not reported concerning the microscopical characters of medicinal plants which can be identified whether genuine medicinal plant resources or not from traditional pharmacies. Therefore, the original diagnostic features and microscopical characters of powder are necessary to know right and exact (Figure 4).

Numerous animals have coevolved with plants. The plant provides a home, food and cloth. Medicines derived from plants and also drugs obtained from plants.
Plants are also a primary source of basic chemicals for the industrial synthesis of a vast array of organic chemicals.

Using medicines derives from plants is a practice probably as old as humankind itself. Many modern medicines are synthetic versions of plant-derived natural products.

Myanmar herbal medicine has been practiced for over 2,500 years since the time of Saya Zewaca. Myanmar traditional medicine is widely practiced and well accepted by many Myanmar people, partly as a supplement and partly as an alternative medicine. Myanmar traditional practitioners use a variety of medicine, mostly containing potent medicinal plants available in Myanmar, for the cure of various diseases.

Due to the lack of systematic teaching of traditional medicine, a tendency to be secretive and reluctance to pass on the knowledge and skills and the custom of handing over the trade only to one’s kith and kin, it has led to loss of many valuable traditional medicine treatises, prescription methods and indigenous medicines. Thus, the potent force of Myanmar traditional medicine gradually declined.

In conclusion, all Universities and Colleges have a great responsibility that is to search and provide the local people’s needs and national needs.

Acknowledgment
My special thanks go to Daw Htay Htay Kyi, Lecturer, Zoology Department, Kalay University who told me the use of *Phyla nodiflora*.

I am greatly indebted to Dr. Yin Yin Mya, Professor and Head of Physic Department, Mandalay University for her kind permission to carry out the determination of relative composition of elements by EDXRF research facilities.

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A Study on cultivation methods of onion (*Allium cepa* L.) in Kyothone-pin village, Kalay Township, Sagaing Region

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Abstract

The present agricultural system in Kalay Township follows the traditional methods which utilize available natural resources combined with improved methods. This paper deals with the cultivation methods of onion in Kyothone-pin village, Kalay Township, Sagaing Region. Three different methods of cultivation are observed. The traditional cultivation and advance type of cultivation are also compared.

Introduction

Onion is the food plant in which the food is stored in a bulb. It is the native of Southern Asia of the Mediterranean region. They are cultivated over large area in temperate and even tropical climate. They thrive best in cool moist regions with a sandy soil (Pandey 2010).

Onion (*Allium cepa* L.) is one of the most important spices as well as vegetable crops of Myanmar. Onion can be grown widely in the tropical region of Myanmar such as Pakokku, Pauk, Magway, Myin-gyan, Monwya, Myittha, etc. The best quality of onion comes from tropical area of Myanmar. Kalay is one of the onion production areas. Study area lies in the western part of Kalay. Western part composed of three wards namely Taungphila, Kyothone-pin and Hlaingthaya. The study area is Kyothone-pin ward. Among them, it is the largest one that was composed of 1494 acres and the size of area is about 1.62 square miles. It is located between the north latitudes 23° 11' and 23° 12' 30" and 93° 58' and 94°1'. Before 2011, Kyothone-pin ward was known as Siyin village tract that composed of seven villages namely Hmulai, Layingsuh, Khintha, Saikhua, Thaya and Khaikam. Humai was the largest

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populated area, Thaya was second and Siyin was the third. Later this village tract is changed into urban ward of Kalay myo. Siyin village tract became to Kyothone-pin ward. Khaikan village is included in Tiddim Township. Kyothone-pin and Hlaingthaya wards are source of rice production depending on the agriculture. Agriculture is major economy of study area. 90 percent of resident people are depending on agriculture.

The shape of study area is elongated and bounded by San myo ward in the east, Tarhan lies in northern and northeast. Indaingon ward on the south and Tiddim Township on the west. Kyothone-pin area composed of large plain and mountain ranges. The elevation of this area is gradually decreased from west to east. Kyothone-pin ward is about 600 ft above sea level. The main flowing streams are Segyi chaung, Ngarant chaung, Yepya chaung and Uboke chaung. All streams flow into Myitthar River. These streams are useful for irrigation because of the perennial types. Major soil types of study area are red brown forest soil, yellow brown forest soil, dark brown forest soil, alluvial soil and meadow soil. The study area composed of sedimentary rock. The hottest month is April and the coolest month is January. The average temperature is 78° F and the maximum temperature is 95° F. Average rainfall is about 75 inches (Source: Department of Geography, 2012).

Depending to the climatic condition, Inding and deciduous forests are found. In, kanyin, Khapaung, Win u, Ingyin, Thitya, Teak, Pyinkado, Htaunk-kyant and bamboo are found sparsely in these forests. Many areas are encountered the deforested condition due to the extension of cultivated fields and buildings (Source: Department of Geography, 2012).

Onion is cultivated in Kalay area for local need. According to data, the largest onion cultivation area are Myo hla, Kyothone pin and Tharsi villages. The range of fields is about 108 to 121 acre. The onion cultivated fields of Kyothone-pin are about 121 acres. Therefore, Kyothone-pin ward is the largest area for onion cultivation. (Source: Land Record Department of Kalay Township, 2012).

Kyothone-pin village is connected the high mountain ranges. Many streams are initiated from the large mountain ranges and irrigated water is available throughout the year. Therefore cultivation of rice is major crop of study area. After harvesting of rice, local people prepare to cultivate the onion. Onion and rice are
cultivated alternately. Onion is one of the important crops in the study area. Many people have been used the traditional method according to the culture and locality. The product of onion is enough to local need but extra onion is exported to the neighboring Regions and countries; India border and Tamu are the important marketing area for onion.

The present study is to provide the information of the traditional methods and advanced methods of onion cultivation and to compare, evaluate the results of two methods of cultivation.

**Materials and Methods**

Location map of Township and village tract were obtained from Land Record Department of Kalay Township. Data of crop plantation, types of crop and their statistical data were provided by Myanmar Agriculture Service and Kalay Township Planning Department. Moreover, the literature concerning with Kyothone-pin was also obtained from Geography Department of Kalay University. The types of onion varieties were provided by the farmers from Kyothone-pin village in Kalay Township.

Method of soil preparation, establishment of nursery plots, transplanting, feeding fertilizers, weeding, caring and harvesting were interviewed to the farmer from study area. The collected specimens from the cultivated fields were identified by referring the references; Flora of British India (Hooker 1885) and Flora of Ceylon (Dassanayake). The experiment was conducted at the fields of Kyothone-pin village, Kalay Township during the raining season of October to April using both local variety (indigenous) and Taung-paw myo. Three different types of cultivation of onion were observed systematically. The materials (Plant specimens) were photo documented in order to illustrate the products (Plant cultivated). The data were compared, analyzed for discussion.

**Morphology**

The onion (*Allium cepa*), which is also known as the bulb onion, common onion and garden onion is the most widely cultivated species of the genus *Allium*. The genus *Allium* also contains a number of other species variously referred to as
onions and cultivated for food. The vast majority of cultivars of *A. cepa* belong to the "common onion group" (*A. cepa* var. *cepa*) and are usually referred to simply as "onions" (Wikipedia 2012).

*Allium cepa* L. Eng. Onion. Family - Liliaceae. The onion is very old, its uses going back over 4000 years. It is probably a native of South Asia or Mediterranean region. It has long been used in China and India. It is the food plant in which the food is stored in a bulb. They are cultivated over large area in temperate and even tropical climates. They thrive best in cool moist regions with sandy soil (Pandy 2007). According to Checklist of the Trees, Shrubs, Herbs, and Climbers of Myanmar, the name of family of *Allium cepa* is Alliaceae (Kress 2003).

**Selection of cultivated fields**

Firstly the appropriate field is selected and then ploughed. In the study area, the sizes of fields are usually small in size due to the condition of topography. Most of the fields are about ¼ acre or ½ acre and most of them are smaller than this size. Large fields that are more than 1 acre or more are rare. The shapes of fields are various forms. Most of them are square, oval, elliptic and even irregular in shapes. These fields are closely connected to each other and are separated by running cannels or streams and barriers. The lands are prepared properly during October and November and fertilized with well decomposed cow dung, urea and other fertilizers.

**B. Selection of Varieties**

Selection of onion seeds is very important for onion cultivation. Local people choose the suitable varieties that are received from the previous ones. Selection of varieties is essential to choose the best quality strain. Two different types of varieties are found in this area namely “local myo and Taung-paw myo”. The varieties vary in yield rate, size and shape. Many peasants believed that the quality of two varieties may be different. The varieties from Phlan and Harka are better than others. Local people call this type as “Taung-paw Myo”(Figure. 1-B). Other type is called as “Lone-pan myo” (Figure. 1-B). The variety comes from “Lone pan area”. According to the locality, the name of strain is known as “Lone pan myo”. The quality of “Lone
“Lone pan myo” is better than local ones. Therefore, the name of Taung-paw myo possesses other different name as “Lone-pan myo”

The color of bulbs of “Lone-pan myo” is bright red and shining. Moreover the size of bulb is usually larger than local ones. The prices of two varieties are different due to the possession of good quality. “Lone pan myo” is usually more expensive than local ones. Moreover production rate is better than other one. The germination’s rate is also better than other. Moreover, the bulb scale quality, the dryness, storage duration and water contents are differ from other ones. The flowering duration of “Lone pan myo” is usually later than local one. Flowering period is important factor because it is related to the yield rate of onion. Flowers can control the growth rate and yield rate of onion bulb. If the onion plant blooms the flowers, the plant can reduce the size of bulbs. Therefore the production of bulbs is earlier than local strain. Lone-pan myo can get the good price. According to this data, Lone-pan myo is more preferred than local one.

The next is “local variety” that comes from Kalay and its surrounding area. It is also known as “Auik-kyin myo”(Figure. 1-A). The price of local variety is fair. Therefore, many peasants decide to choose the local varieties. This variety is suitable for current environment. This type is abundantly used in this area. The size and quality of bulbs are not very different from “Taung-paw myo”.

The size, color and weight of seeds are very similar to each other. No one can distinguish two varieties. In the study area, two varieties can be bought from Kalay area. The price of two varieties is not same. In previous years 2008-09, one cup (pyi taung) of seeds was about 4000 kyats for local one and 5000 kyats for Lone pan myo. The next years 2010-11, 7000 kyats for local one and 10000 kyats for Lone pan myo. In this year 2011-2012, the price reaches the greatest rate, 15000 kyats for local ones and more than 20000 kyats for Lone pan myo.

The amount of onion seeds per acre may be variable. Standard rate is four cups (pyi taung) for one acre. According to observed data, one (pyi taung) bass of seeds can produce at least 1000 viss (peik tha). 1 vass of strain can grow more than one acre. According to estimated data, one acre of onion field can yield more than 5000 viss.
Onion Cultivation

Type of cultivation

There are three types of onion cultivation commonly used in the studied area.

i. Direct seed cultivation

ii. Transplantation of seedling and

iii. Direct small bulblets cultivation

i. Direct seed cultivation

This method of the cultivation is very simple and old because onion seeds are much cheaper than seedlings. In previous time, local people used this method. In this type includes 4 steps. They are (1) burning straw (2) irrigation (3) broadcasting seeds and (4) covering the straws and (5) elimination of weeds.

(1.) Burning straws (Figure. 1- E)

After harvesting the rice or wheat fields, the fields are filled with the dried stalk of the grain known as straws known as “Yo pyat” (Figure 1 D). The dried straws are spread the entire fields. Then, the fields are burnt with fire. Within a very short time, the whole field is filled with burnt straws and ash(Figure 1 F) . Peasants believe that the ash of straw is major important materials for germination of onion. Moreover, the burning fire can kill the seeds of weeds and many insects. Burning straw keeps the field absolutely free from weeds to produce a good crop of onion. Weeds if not controlled in early stage but removed later on, will injure the onion bulbs and the quality of onion will be poor.

(2.) Irrigation (Fig 1- G)

After burning the straw, irrigation is started. Before irrigation, peasants block carefully the entrances and outlets of fields to prevent the loss of water. The water is gradually mixed with burned straw ash to form homogeneous soft mud. Irrigation is prolonged about one to two weeks according to soil types. But in study area, irrigation
can be finished within one or two days. Slow irrigation is necessary to prepare the good nursery. High speed irrigation can eliminate the important nutrients and straw ash from the upper surface of soil. Irrigated water should be stored in nursery field till broadcasting the seeds. The irrigated water with straw ash may contain essential nutrients for seedlings of onion. After irrigation, the water is totally absorbed by cultivated field within 2 or 4 hours according to the soil type. Many peasants believe that the harrowed fields can encourage the survivability of weeds therefore many peasants avoid harrowing the fields before irrigation. Flooded water can kill the growth of small weeds and insects.

(3) Broadcasting seeds (Figure 1 G)

After irrigation, the cultivated field is gradually changed into nursery to propagate the onion. According to the procedure, irrigation is carried out at the morning period but the seeds should be broadcasted at the evening. Peasants have broadcasted the seeds manually due to the size of seeds. Onion seeds are minute in size. Peasants should spread the onion seeds evenly throughout the mud of the fields. It is very important step because the seeds can be accumulated at the corner of the fields due to the irrigation of water. Crowded germination of seed can reduce the rate of onion production. The animals manure and some humus are added as natural fertilizer. In this type, synthetic chemical fertilizer is rarely used. The common fertilizer was the “urea” or “Pale fertilizer” that may be used for vegetative growth of seedlings.

(4) Covering the straws (Figure 2 A-B)

The covering of the straw is very important step. After broadcasting seeds, the dried straws are evenly spread on the seeds. Dried rice straws are commonly used. Wheat straw is rarely used. The straws are laid on evenly the entire fields. The thickness of the straws is about 3.0 to 4.0 inches. The thicker the thickness of dried straws, the lower the survival rate of weeds. The thickness of straw is important matter because the dried straw can prevent the germination of weeds. If the layer of straw is thin, the weed can grow easily and emerge above the straws. In contrast, if the layer of straw is thick, the germination of weeds is markedly decreased. After
covering the straw, the irrigation can be started again. In this step, peasants should irrigate carefully. Strong current of water can remove the onion seeds from original place to another one. According to strong water current, the crowded seedlings can be found at the corner of the field. After 2 or 3 weeks, the young seedlings emerge through the straws. The leaves of young seedlings are very delicate and easily breakable. Therefore they need prevention from the mechanical injury. Dried straw can also create the moist and shady condition at the bottom of plant. This condition is suitable and supplies the essential water and mineral salts for the growing bulb. The roots can easily absorb nutrients and water. Furthermore, the shady place (no sunlight) can delay the growth of various weeds.

(5) Elimination of weeds (Figure 2 C)

Weeds are the problem manner of onion cultivation. Numerous weeds gradually invade between the growing onion plants and later they form the large bulky plants. The weeds can decrease the production of onion. Peasants should not eliminate the weeds until 45 days because the roots of seedling are very delicate. When the weeds are removed from the soil, the straws may be held carefully. After 50 days, peasants can remove all weeds by using worker on daily wages. The small herbaceous weeds cannot survive in this condition except large erect shrubs. Large weeds can easily be removed from the onion fields. For example, *Xanthium* spp: and *Polygonum* spp: are the prominent weeds and are about 2 to 3 feet high. Many weeds can be found along the bank of barrier (Baung). *Polygonum* spp:, *Mallilotus alba*, *Chenopodium album* and *Oxalis* spp: are abundantly found as common weeds. Some peasants rarely used many chemical weed killers.

(6) Irrigation after covering the straw (Figure. 2 A-B)

Irrigation of water takes 15 days after sowing the seeds according to saturation of fields. Some farmers irrigate the water once a week. According to the soil condition, the irrigation of water may be different. Many cultivated fields are associated with the streams. Excess irrigation can damage the young onion plants. Therefore regular irrigation is an important task. After irrigation, the water supply is cut off about 2 to 3 weeks. According to moisture of soil condition, next irrigation
will be taking after 3 weeks. In this type, the problem of weeds is insignificant. Elimination of weeds is not required. Humus and chemical fertilizer such as urea “pale” are added into field as nutrients.

2. Transplantation of seedling

The second method is popular and advanced type and it is extensively used in studied area. Initially the appropriate area is chosen to make the nursery beds. The size of this area is not too large and about 5-10 m² in diameter or lesser than this size. This method is more advanced than previous one. This method consists of 4 steps namely (i) preparation of nursery (2) elimination of weeds (3) pull out seedling for transplanting (3) Preparation of field (4) cultivation of seedlings.

(i) preparation of nursery (Figure 2- E)

Preparation of nursery starts after harvesting of rice fields at November or December. Firstly appropriate field is selected and ploughed. The size of field may be ¼ to 1/6 acre. Animal manure and natural fertilizer are added to this field. Some people use the synthetic fertilizers such as Urea. After ploughing, seed beds can be prepared. The width of seed beds may be 3 to 4 ft and 15 to 30 ft long or more. The height of nursery bed is 12 to 20 cm. Between two beds are separated by a channel for irrigation.

The seeds are sown evenly spread on these beds. The young nursery plants are protected from intense sunlight by covering dried straws or not. The nursery plants are watered two times daily before transplantation. Irrigation is also important for this step. After one or two weeks, the seeds germinate into seedlings. Suitable irrigation is required one or two time in a week.

(ii) Elimination of weeds (Figure 2- F)

Weeds are major problems of this step. Various types of weeds are growing on nursery bed. In young seedling of weeds can be removed by manually (done by hands). After 5 days, the elimination of weeds should be started because the roots of weeds can interfere the growth of onion seedlings. The workers on daily wages
remove carefully the weeds from seed beds. Some cultivars rarely use the synthetic weed-killer but in the study area most of them rely on man power. Elimination of weeds is very important task therefore many workers are required. According to data, 10-15 workers are used for nursery beds for 1 acre onion cultivated field in each day.

(iii) **Pull out seedling for transplanting** (Figure 2- G-H)

After 15 days, the size of seedlings will be reached about 6 inches or more that is suitable for transplanting. In this period, the irrigation of nursery bed is ceased. The cultivars pull out gently the seedlings from seed beds and then make the bundles of seedlings.

(iv) **Preparation of onion fields** (Figure 2-I-J)

After harvesting the paddy fields, the fields are prepared for onion cultivation. October to November is the proper season to prepare the fields. The soil is aided with animal manure, suitable chemical fertilizers, humus and burned ash of straw. The field is ploughed by tractors or animals. Then, the ploughed fields are divided into many frames or “baung”. The size of each plot is about 3.0 - 4.0 ft wide and 30-50 ft long or more. The shallow channels are made between two plots to supply the irrigated water. The width of channel is about 6 inches. This condition is ready to transplant the seedlings. In this area, continuous irrigation is important manner because the moisture contents of soil may enhance the growth rate of seedlings. Synthetic chemical fertilizers are used namely urea. But many farmers usually use natural fertilizers.

(v) **Transplantation of seedlings.** (Figure 3. A-C)

After preparation of fields, transplantation of seedling should be started. The seedlings are planting row by row. Each row consists of 10-15 plants. The length of seedlings may be 1.5 to 2.0 inches between them. The transplantation of seedling is done by hand. After cultivation, the water is filling up to reach the base of onion seedlings. The moisture contents are evenly spread throughout the field due to the entrance of water. The roots of onion can penetrate deeper than 15 cm. Water
requirement at the initial growth period is less. Irrigation should be stopped 15-20 days before attaining maturity for improving the keeping quality of bulbs. Frequent irrigation delays maturity.

3. Direct small bulb cultivation (Figure 3. D-E)

Although onion can be propagated by either seeds or young seedlings, the third type of cultivation is done by small bulblets that received from previous year. Direct small bulblets cultivation is preferred and gives excellent results to get early the mature onion buds. These onion bulbs can be sold with high price in onion market. It is the special method of cultivation therefore it is not commonly used. In this type, small buds are used instead of using onion seeds. Onion buds, are a little bit more expensive than seeds, but can be planted directly in the fields. These plants can easily be planted in these fields very quickly and will produce onions in 60 days. The size of buds may be 1.0 to 2.0 cm in diameter. The buds are selected from the previous strain. The cultivation method of this type has two steps (i) burning straws (ii) preparation of fields and cultivation of onion.

(i) Burning the straw

This step is similar to the previous one.

(ii) Preparation of fields and cultivation

In this step, two different types are found. Many farmers used the old method. After burning the straws, the direct irrigation is started. The moist soft mud is suitable for cultivation of onion. The small buds are cultivated randomly. After planting the bud onion, dried straws are covered above these buds. The covering straw may be about 2 to 4 cm in thickness. Some farmers ploughed after burning the fields and then make many frames. Small buds are planted evenly on these frames. Space the holes about 2 cm apart. If planting multiple rows, space the rows at least 12 cm apart. The covering straws are not needed. After planting onion bulbs, irrigated water them.
B. Harvesting of Onion plants

After 3 or 4 months, the mature bulbs are ready to harvest. Onions are ready for harvest when the leaves collapse. In January, the large mature leaves are gradually grown out of the straws. The length of mature leaves is about 1.5 to 2 feet. Harvesting method is very simple and done by hand. The soils are removed from the bulbs. Then the partially dried leaves and adventitious roots are cut by using the special curved knife (Tazin). Sometimes the entire plants are gathered into a large bundle and they are carried by bullock cart or vehicles to homes. Cutting leaves and roots may be made at home or in the fields. The residue of leaves and roots can be recycled for natural fertilizer. After cutting leaves and roots, the bulbs are spread on the ground or mats for air dryness about one week. Yield rate are counted randomly from each plot. Data are analyzed and construct proper graphs.

Conclusion

This paper deals with the study of three different types of cultivation of onion from Kyothone-pin village. Onion cultivation becomes more and more popular among the other crop’s cultivation. It is the second largest crop in the studied area. In this paper, the procedures of cultivation are expressed step by step. According to collected data, the transplanted seedling cultivation is the majority but direct seed cultivation is minority. Direct small bulb cultivation is rarely found in the study area.

The three types of cultivation of onion possess many advantages and disadvantages. The direct seed cultivation which is old traditional type, have many advantages such as (1) it requires small area to cultivate the onion (2) ploughing of field is not required (3) the heat from burning straws can eliminate the destructive insects and their offspring (4) the burning ash can get better the soil fertility (5) the nursery bed preparation not required (6) using natural fertilizers that can improve the fertility of soil condition (7) It needs a few workers to prepare the fields (8) using the dried straws that cover the seedling (9) dried straws can control the moisture contents of soil and prevent the young seedlings from direct intense sunlight (10) the thickness of dried straw can reduce the growing of weeds (11) a few workers are used to harvest the mature onion and (12) the production of the large size of onion.
Moreover, many disadvantages are also found in this type such as (1) this type represents the small mass production (2) unequal growth rate of seedlings (3) production of water enriched bulbs that cannot be stored longer (4) production of lower quality of bulbs (Figure 3 J) (5) production of lower price of bulbs and (5) low rate of yield per acre.

Similarly, the second type of onion cultivation also possesses both advantages and disadvantages. The advantages are (1) large amount of onion bulbs can be produced by this type (2) using advanced agricultural method (3) using synthetic fertilizers (4) production of high yield rate of onion per acre (5) production of good quality of onion bulbs (Figure 3 I) and (6) high price can be got.

The many disadvantages are also found in this type such as (1) requirement of nursery bed (2) ploughing fields to prepare the cultivated fields (3) using synthetic chemical fertilizers that can destroy the natural soil (4) using weed killers and insecticides (Figure 3 G-H) that can also harm the nature of other plants and human’s health (5) using of many workers to prepare the nursery fields, land preparation of cultivated fields, weeds elimination from nursery fields, cultivated fields and harvesting of onion bulbs. Therefore, many workers are required to finish the process within one day. According to data, 15 to 20 workers are needed to cultivate seedling for one acre. The total charges are about 40000 to 60000 kyats for one acre.

The effect of cultivation types on the growth rate and quality of bulbs is estimated by measuring the size and yield rate from two different varieties of onion strain.

In the present investigation, the good enhancement of growth rate and yield rate were found in the second type of cultivation. It was possible that the good yield rate may be due to the proper irrigation and ventilation of soil. Moreover, the old traditional cultivation of onion has been used till the present period because they did not know how to do this. Many residents are poor and uneducated. Most of them possess the small area of cultivated fields. Therefore they want to cultivate the onion by using traditional method. They believed that it is the cheapest method among them. Most of them believe that burning ash is the good fertilizer. Many dried straw were lost by burning in the fields. These straws can be applied other manners such as animal fodders, cultivation of mushroom and etc. A few peasants know how to
cultivate onion by modern method. They use best strain of onion to get the best quality of yield rate and bulbs.

In conclusion, this paper is to provide information of three type of cultivation of onion in Kyothone-pin village, Kalay Township. We hope that this paper may be useful and helpful to the future workers.

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Figure 1. A. The seeds of Auik-kyin myo (Local myo)  
B. The seeds of Lon-pan myo (Taung paw myo)  
C. Seed of Lon-pan myo (in detail)  
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J. The bulb from direct seed cultivation method
Table 1.

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CHARACTERIZATION OF $\alpha$-AMYLASE ENZYME
FROM MALUS DOMESTICA (APPLE)

Khin Nann Nyunt Swe*

Abstract

In this research work, apple was purchased from Mya Nandar market, Chan Mya Tharzi Township, Mandalay Region. Apple was homogenized in phosphate buffer solution (pH 7) for $\alpha$-amylase enzyme extraction. The crude $\alpha$-amylase enzyme was partially purified by ammonium sulphate precipitation method. 0.13% of crude $\alpha$-amylase enzyme was obtained. $\alpha$-amylase action on soluble starch was well characterized by using iodine staining method. In this study, a blank solution containing the mixture of starch and distilled water showed deep blue color with iodine solution, whereas solution mixture of enzyme and starch solutions showed no color with iodine solution. The enzyme properties such as optimum pH, optimum temperature, effect of reaction time were determined by UV-visible spectroscopic method. From this determination, $\alpha$-amylase enzyme showed optimum pH of 6.8, optimum temperature of 37°C and incubation time for enzyme assay was 10 minutes.

Introduction

Enzymes, the catalysts for the biochemical reaction occurring in all living organisms are proteins (Harrow and Sherwin 1935). The enzymes are important and essential compounds of biological systems. Their functions belong to catalyze the chemical reactions that are essential to life (Johnson 1977). All enzymes are proteins or consists of a protein simple or conjugated (Lehninger 1975). Enzymes occupy an important place in analytical biochemistry (Homes and Peck, 1994). Most enzymes are much larger than the substrates they act on, and only a small portion of the enzyme (around 3-4 amino acids) is directly involved in catalysis.

The region that contains these catalytic residues, binds the substrate and carries out the reaction is known as the active site. Enzymes can also contain sites that bind cofactors, which are needed for catalysis. Some enzymes also have binding sites

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for small molecules, which are often direct or indirect products or substrates of the reaction catalyzed. This binding can serve to increase or decrease the enzyme’s activity, providing for feedback regulation.

Amylases have been subdivided into various groups, since, the reaction which they catalyze, can produce according to several different mechanisms (Boyer 1960). Microbial amylases are potentially useful in pharmaceutical and fine chemical industries (Augustin et al, 1981, Pandey et al, 2000). Amylases are among the most important enzymes and are of great significance in present day biotechnology especially in bread baking process. After the addition of enzyme, bread volume increases and retains its softness (Ammaret al, 2002).

The spectrum of application has widened in many other fields such as clinical, medical and analytical practices (Aktinson and Movilunc, 1991). Alpha – amylase is monomeric, calcium binding glycoprotein. Its single polypeptide chain has 496 amino acid residues with four disulfide bridges. In fruits amylase activity is correlated with the fruit ripening and climacteric rise in respiration. During ripening period, starch content of fruits are degraded in a complex process involving α and β amylases as well as (1-4 and 1-6) glucosidases (Lajalo, 2001).

Amylases are important enzymes employed in the starch processing industries for the hydrolysis of polysaccharides such as starch into simple sugar constituents (Advet al; 2005). Amylase can be obtained from several sources, such as plants, animals and microorganisms. Alpha amylase (1,4 - α - D – Glucan Glucanohydrolase) was widely documented in the industries of starch sugar (glucose, maltose, dextrin, fructose and Oligosaccharide), alcohol, beer, monosodium glutamate, brewing, organic acid, print, dyeing, paper making and other fermentation processes (Alvael al, 2007). The main aim of this research work is to isolate and characterize α- amylase enzyme from *Malus domestica* (Apple).
Botanical Description

Figure 1: Apple tree

Family name : Mimosaceae

Botanical Name : Malus domestica

Figure 2: Apple fruit

English Name : Apple

Myanmar Name : Pan Thee

Aim

To study the isolation and characterization of α - amylase enzyme extracted from Malus domestica (Apple).

Experimental

Materials and Methods

Sample Collection

Apple was purchased from Mya Nandar market, Chan Mya Tharzi Township, Mandalay Region.

Chemicals

Sodium dihydrogen phosphate and disodium hydrogen phosphate from BDH, ammonium sulphate from Kanto were used.

Extraction of α-Amylase Enzyme from Apple

Procedure

Apples were peeled and blended in a blender for 10 min. Soft thalamus of apple (100g) was taken in 400 ml of 0.1 M sodium phosphate buffer solution (pH-7)
and stirred for 10 min at room temperature. Then, suspension was filtered. The filtrate was cooled and centrifuged at 10000 rpm for 15 min and supernatant (350 ml) was separated from sediment. Solid ammonium sulphate (79.1g) was added to the supernatant to give 40% saturation.

After standing for 4 hours at 4°C, the precipitate was removed by centrifugation for 15 min at 10000 rpm and was discarded. Additional ammonium sulphate (36 g) was then added to the solution (300 ml) to give 60% saturation. After standing for 4 hours at 4°C, centrifugation was continued for 15 min at 10000 rpm. Supernatant was discarded. Finally crude enzyme extract was obtained. The crude enzymes were kept in refrigerator at 4°C.

Qualitative Examination of Apple α-Amylase Activity

Procedure

A test tube containing 1 ml of enzyme solution was labelled as tube A and another tube containing 1 ml of distilled water was labelled as tube B for blank solution.
4 ml each of 2% starch solution was added into test tubes A and B, then the contents were mixed well and stand for 30 min. And then, 0.1 ml each of iodine solution was added into tubes A and B, respectively.

**Determination of Wavelength of Maximum Absorption of Arsenomolybdate Chromogenic Compound in Nelson-Somogyi Method**

**Procedure**

A 0.5 ml of standard maltose solution I was pipetted into a test tube containing 1 ml of alkaline copper reagent solution and the contents were mixed well (Whistler. 1965 and Oser. 1976). The test tube was heated on a vigorously boiling water-bath for 10 min. Next the test tube was cooled under running tap water for 1 min and 1 ml of arsenomolybdate colour reagent solution was added into the test tube. The solution mixture gave a greenish blue colour after shaking vigorously. This solution was diluted to 10 ml with distilled water and mixed by inversion. The arsenomolybdate chromogenic solution was obtained. Similarly, 0.5 ml of standard maltose solutions II, III, IV and V were prepared according to the above procedure.

A blank solution was prepared by carrying out the procedure as described above except that 0.5 ml of distilled water was used instead of 0.5 ml of standard maltose solution. The range of wavelength was fixed between 600 and 800 nm. Then the blank solution was transferred to the reference cell and placed in the reference cell holder. The sample solution was transferred to the sample cell and placed in the sample cell holder, and the data was recorded. The wavelength of maximum absorption of arsenomolybdate chromogenic compound was found at 750 nm.

**Construction of Calibration Curve for Arsenomolybdate Chromogenic Compound**

**Procedure**

This procedure was the same as that described in above. The absorbances of five arsenomolybdate chromogenic solutions obtained from standard maltose solutions, I, II, III, IV and V were measured at 750 nm against the blank solution with
a UV-visible spectrophotometer. Then the plot of absorbance against concentration of standard maltose solutions was done.

**Effect of Reaction Time on α-Amylase Catalyzed Reaction**

**Procedure**

A 0.1 ml of 2% starch solution was pipetted into a test tube containing 0.1 ml of pH 7 phosphate buffer solution (0.1 M). Then 0.1 ml of prepared enzyme solution was added and the contents were mixed well. After 2 min, 0.1 ml of the above solution mixture was transferred to a test tube containing 1 ml of alkaline copper reagent solution and the contents were mixed thoroughly. The test tube was heated on a vigorously boiling water-bath for 10 min. Next the test tube was cooled under running tap water for 1 min and 1 ml of arsenomolybdate colour reagent solution was added into the test tube. The solution mixture gave a greenish blue colour after shaking vigorously.

Each 0.1 ml from the reaction mixtures was transferred and treated similarly for 4, 6, 8, 10, 12 and 15, 20 minutes.

For blank solution, 0.1 ml of distilled water was used instead of 0.1 ml of the prepared enzyme solution. The wavelength was fixed at 750 nm. Then the blank solution was transferred to the reference cell and placed in the reference cell holder. The sample solution was transferred to the sample cell and placed in the sample cell holder, and the data was recorded.

**Effect of pH on α-Amylase Catalyzed Reaction**

**Procedure**

A 0.1 ml of pH 1 hydrochloric acid-sodium chloride buffer solution was pipetted into a test tube containing 0.1 ml of starch solution (2%), then 0.1 ml of prepared enzyme solution was added and the contents were mixed well. After 10 min, the reaction was interrupted by adding 1 ml of alkaline copper reagent solution. The contents were then mixed thoroughly. The test tube was heated on a vigorously boiling water-bath for 10 min. Next the test tube was cooled under running tap water
for 1 min and 1 ml of arsenomolybdate colour reagent solution was added into the test tube. The solution mixture gave a greenish blue colour after shaking vigorously.

For blank solution, 0.1 ml of distilled water was used instead of 0.1 ml of the prepared enzyme solution. Then the blank solution was transferred to the reference cell and placed in the reference cell holder. The sample solution was transferred to the sample cell and placed in the sample cell holder and the absorbances were measured at 750 nm against the blank solution.

The whole of the above procedure was repeated with pH 2 (Hydrochloric acid-sodium chloride), pH 3,4 and 5 (Acetate), pH 6, 6.2, 6.5, 6.8, 7 and 8 (sodium phosphate), pH 9 and 10 (sodium carbonate-bicarbonate) buffers.

**Effect of Temperature on \( \alpha \)-Amylase Catalyzed Reaction**

**Procedure**

A 0.1 ml of 2% starch solution was pipetted into a test tube containing 0.1 ml of phosphate buffer (pH 6.8) solution and the contents were mixed well. A 0.1 ml of enzyme solutions was pipetted into another test tube. They were kept at 5°C for 10 min to reach each the thermal equilibrium. The former solution mixture was poured into a test tube containing 0.1 ml of enzyme solution and the content were mixed well. Then the solution mixture was placed in incubator at 5°C. After 10 min incubation, 1 ml of alkaline copper reagent solution was added to stop the reaction. The test tube was heated on a vigorously boiling water-bath for 10 min. Next the test tube was cooled under running tap water for 1 min and 1 ml of arsenomolybdate colour reagent solution was added into the test tube. The solution mixture gave a greenish blue colour after shaking vigorously. For blank solution 0.1 ml of distilled water was used instead of 0.1 ml of the prepared enzyme solution.

Then the blank solution was transferred to the reference cell and placed in the reference cell holder. The sample solution was transferred to the sample cell and placed in the sample cell holder and the absorbance were measured at 750 nm against the blank solution. Similarly the new sets of reaction mixtures were allowed to react at temperature of 10, 20, 25, 30, 35, 37, 39, 40, 50, 60, 70 and 75°C, respectively.
Results and discussion

Extraction of α-Amylase Enzyme from Apple

In this research work (chapter 3.1), the α- amylase enzyme was extracted from apple by using the solution mixture of sodium dihydrogen phosphate and disodium hydrogen phosphate buffer (pH 7) solution. α - Amylase enzyme was partially purified by using ammonium sulphate (40% saturation and 60% saturation) precipitation method. 0.13% of crude α-amylase enzyme was obtained. Ammonium sulphate is the most commonly used reagent for salting out the proteins because of its high solubility that permits the achievement of the solutions with higher ionic strength.

Qualitative Examination of α-Amylase Activity by Using Iodine Staining Method

Qualitative examination of α - amylase action was done by using iodine staining method (Harper 1997 and Oser 1976). Starch gives a blue colour with iodine. It appears to be an absorption complex of starch and iodine rather than a definite compound. The disappearance of blue color, therefore, reveals the decomposition of starch polymer by enzyme action.

In this study, a blank solution containing the mixture of starch and distilled water showed deep blue color with iodine solution, whereas a test tube containing solution mixture of enzyme and starch solution showed no color with iodine solution.

Wavelength of Maximum Absorption of Arsenomolybdate Chromogenic Compound in Nelson-Somogyi Method

The electronic transitions that take place in the visible and ultraviolet regions of the spectrum are due to the absorption of radiation by specific types of groups, bonds and functional group within the molecule. The wavelength of absorption and the intensity are dependent on the type. The wavelength of absorption is a measure of the energy required for the transition (Shinke. 1986). For quantitative analysis of a compound by visible spectroscopy, it is firstly necessary to know the wavelength of maximum absorption ($\lambda_{\text{max}}$) (Varely, 1980). In determination of ($\lambda_{\text{max}}$) of
arsenomolybdate chromogenic compound, the standard maltose solution and reagents of Nelson and Somogyi were used (Nelson 1944 and Balley. 1957).

Theoretically, starch is hydrolyzed by the enzyme diastase (α-amylase) to maltose (Pigman 1965). By using the Nelson-Somogyi reagent, R.L Wistler (Wistler and Walform. 1965) studied the determination of reducing sugar by measuring the absorbance of arsenomolybdate chromogenic compound formed from reduction by sugar. The Somogyi reagent also known as an alkaline copper reagent is used to interrupt the reaction of enzyme (α-amylase) on starch and oxidative form of complex copper II included in an alkaline copper solution is also reduced by the sugar, specifically maltose (Day and Underwod, 1958). Thus the reducing units of copper is equivalent to the unit to maltose formed by α-amylase hydrolysis of starch. The Nelson reagent also termed as arsenomolybdate color reagent is used to measure the reducing power of maltose.

In this research, the absorption data of arsenomolybdate chromogenic compound was recorded in the range from 600-800 nm and the wavelength of maximum absorption was found at 750 nm.

Construction of Calibration Curve for

Arsenomolybdate Chromogenic Compound

After deciding upon the conditions for the analysis, it is necessary to prepare a calibration curve from a series of standard solutions. These standards should cover a reasonable analyte concentration range. In the determination of various concentrations of maltose with absorbance of reduced arsenomolybdate chromogenic compound, by using the Nelson-Somogyi reagents, different concentrations of maltose solutions were used to draw the calibration curve for standard maltose (Oser. 1976).

In this study, the absorbance values at 750 nm were obtained for different maltose concentrations by using a UV-visible spectrophotometer. It was found that the nature of the plot of absorbance vs concentration of maltose (Table: 2 and Figure: 11) was a straight line passing through the origin showing that Beer's law was obeyed.
Effect of Reaction Time on $\alpha$-Amylase Catalyzed Reaction

The reaction time is an important factor in determining the enzyme activity. Optimum temperature is partly based on the reaction time. The optimum temperature for enzyme activity increased inversely with the increase in reaction time.

Alpha amylase enzyme activity was measured spectrophotometrically by monitoring the increase in absorbance at 750 nm in UV-visible spectrophotometer. Among the other conditions which control the rate of an enzymic reaction, time is an important factor in the determination of enzyme activity (Anderson, 1972).

In this study, the action of the $\alpha$-amylase on soluble starch was studied in phosphate buffer of pH 7. The changes of absorbance during the various reaction times of 2, 4, 6, 8, 10, 12, 15 and 20 were determined by Nelson-Somogyi method.

Effect of pH on $\alpha$-Amylase Catalyzed Reaction

Enzymes are very sensitive to change in pH and each enzyme functions best within a very limited range called its optimum pH. The pH has a marked influence on the rate of enzymic reaction. Characteristically, each enzyme has a pH value at which the rate is optimal and on each side of this optimum, the rate is lower (Lehninger, 1975).

In this research, hydrochloric acid-sodium chloride buffer, acetate buffer, phosphate buffer, sodium carbonate-bicarbonate buffer of pH values ranging from 1 to 10 were used to determine the activity of the prepared $\alpha$-amylase. The activity vs pH curve of the enzyme was drawn and it was found that the optimum pH for maximum activity of $\alpha$-amylase was pH 6.8. The optimum pH 6.8 is in agreement with the literature (Wiseman, 1975) range of pH 5.5 to 8.5 for $\alpha$-amylase.

Effect of Temperature on $\alpha$-Amylase Catalyzed Reaction

Generally, an increase in temperature is accomplished by an acceleration of a chemical reaction. The rate of an enzyme-catalyzed reaction first increases with the increase in temperature and then decreases by thermal denaturation (Oser, 1976).
For each enzyme, there is a certain temperature called the optimum temperature at which the enzyme activity is maximum and the activity progressively falls both above and below this temperature (Oser 1976). The optimum temperature of each enzyme is largely dependent on the incubation time and the nature of the incubation medium.

In this research, the dependence of activity on temperature was shown in Fig 4.6. The activity of $\alpha$-amylase increased as the temperature increased. From the plot, the optimum temperature for $\alpha$-amylase was found at 37°C.

### Table (1): Relationship between Absorbance of Arsenomolybdate Chromogenic Compound and Concentration of Standard Maltose Solution

<table>
<thead>
<tr>
<th>Standard maltose solution</th>
<th>Maltose concentration $\times 10^{-4}$ (M)</th>
<th>Absorbance 750 nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>2.222</td>
<td>0.310</td>
</tr>
<tr>
<td>II</td>
<td>2.775</td>
<td>0.421</td>
</tr>
<tr>
<td>III</td>
<td>3.885</td>
<td>0.559</td>
</tr>
<tr>
<td>IV</td>
<td>4.995</td>
<td>0.740</td>
</tr>
<tr>
<td>V</td>
<td>5.55</td>
<td>0.841</td>
</tr>
</tbody>
</table>

### Table (2): Relationship between $\alpha$-Amylase Activity and Reaction Time

<table>
<thead>
<tr>
<th>Reaction Time (min)</th>
<th>Activity (μ mole min$^{-1}$ ml$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3.00</td>
</tr>
<tr>
<td>4</td>
<td>3.40</td>
</tr>
<tr>
<td>6</td>
<td>3.80</td>
</tr>
<tr>
<td>8</td>
<td>4.20</td>
</tr>
<tr>
<td>10</td>
<td>4.40</td>
</tr>
<tr>
<td>12</td>
<td>4.10</td>
</tr>
<tr>
<td>15</td>
<td>4.00</td>
</tr>
<tr>
<td>20</td>
<td>3.60</td>
</tr>
</tbody>
</table>
Table (3): Relation between α-Amylase Activity and pH of Solution

<table>
<thead>
<tr>
<th>No</th>
<th>Types of Buffer</th>
<th>pH</th>
<th>Activity (µ mol min⁻¹ ml⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HCl, NaCl</td>
<td>1</td>
<td>0.20</td>
</tr>
<tr>
<td>2</td>
<td>HCl, NaCl</td>
<td>2</td>
<td>0.30</td>
</tr>
<tr>
<td>3</td>
<td>acetate buffer</td>
<td>3</td>
<td>1.00</td>
</tr>
<tr>
<td>4</td>
<td>acetate buffer</td>
<td>4</td>
<td>1.50</td>
</tr>
<tr>
<td>5</td>
<td>acetate buffer</td>
<td>5</td>
<td>1.80</td>
</tr>
<tr>
<td>6</td>
<td>phosphate buffer</td>
<td>6</td>
<td>3.00</td>
</tr>
<tr>
<td>7</td>
<td>phosphate buffer</td>
<td>6.</td>
<td>3.90</td>
</tr>
<tr>
<td>8</td>
<td>phosphate buffer</td>
<td>6.</td>
<td>4.10</td>
</tr>
<tr>
<td>9</td>
<td>phosphate buffer</td>
<td>6.</td>
<td>4.95</td>
</tr>
<tr>
<td>10</td>
<td>phosphate buffer</td>
<td>7</td>
<td>4.60</td>
</tr>
<tr>
<td>11</td>
<td>phosphate buffer</td>
<td>8</td>
<td>2.50</td>
</tr>
<tr>
<td>12</td>
<td>sodium carbonate-bicarbonate</td>
<td>9</td>
<td>1.20</td>
</tr>
<tr>
<td>13</td>
<td>sodium carbonate-bicarbonate</td>
<td>10</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Table (4): Relationship between α-Amylase Activity and Temperature of the Solution

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Activity(µ mole min⁻¹ ml⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1.10</td>
</tr>
<tr>
<td>10</td>
<td>2.20</td>
</tr>
<tr>
<td>20</td>
<td>3.70</td>
</tr>
<tr>
<td>25</td>
<td>3.90</td>
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<tr>
<td>30</td>
<td>4.25</td>
</tr>
<tr>
<td>35</td>
<td>4.25</td>
</tr>
<tr>
<td>37</td>
<td>4.40</td>
</tr>
<tr>
<td>39</td>
<td>4.30</td>
</tr>
<tr>
<td>40</td>
<td>4.20</td>
</tr>
<tr>
<td>50</td>
<td>3.80</td>
</tr>
<tr>
<td>60</td>
<td>3.60</td>
</tr>
<tr>
<td>70</td>
<td>2.90</td>
</tr>
<tr>
<td>75</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Fig 9: α-Amylase Activity on Starch

Fig: 10 Wavelength of Maximum Absorption of Arsenomolybdate Chromogenic Compound

Figure 11. Calibration curve for the Standard Maltose Solution

Fig: (12) Effect of Reaction Time on α-Amylase Activity from Apple.
Conclusion

In this research paper, apple was purchased from Mya Nandar market, Chan Mya Tharzi Township, Mandalay Region. The sample came originally from Shan State.

The crude \( \alpha \)-amylase enzyme was extracted from apple by using 0.1 M phosphate buffer (pH-7) containing a mixture solution of sodium dihydrogen phosphate and disodium hydrogen phosphate. The crude \( \alpha \)-amylase enzyme was partially purified by using ammonium sulphate precipitation method. The yield percent of crude \( \alpha \)-amylase enzyme extracted was found to be 0.13%.

Qualitative examination of \( \alpha \)-amylase action was done by using iodine staining method. In the iodine staining method, experiments were carried out for \( \alpha \)-amylase and \( \alpha \)-amylase free solutions. Due to the formation of iodo-starch complex with the addition of iodine, the blank solution gave a blue color with iodine. However, no change in colour with the addition of iodine was observed for solution mixture of \( \alpha \)-amylase and starch solution due to the starch-hydrolyzing enzyme.

In accordance with the experimental data, the enzyme (\( \alpha \)-amylase) obtained maximum activity after the time interval of 10 min. This enzyme showed the optimum activity at pH 6.8 (with activity of 4.95 \( \mu \) mol min\(^{-1}\) ml\(^{-1}\)) and by increasing or decreasing the pH from the optimum pH, the activity of enzyme was decreased. And also the thermal effects on \( \alpha \)-amylase revealed that with increasing temperature from 0-37°C, the activity of enzyme was maximum at 37°C. With further increase in temperature, there was a drastic decrease in activity which might be due to
denaturation of enzyme. Thus, the optimum temperature was found to be 37°C indicating 4.40 μmol min⁻¹ml⁻¹ activity.

Acknowledgements

The author would like to express my sincere gratitude to Acting Rector U Myint Swe, Pro-Rector Dr U Pwa, Kalay University for their encouragements for my research. The author would like to deeply thank to Dr Aung Kyaw Win, Professor and Head, Department of Chemistry, Kalay University for their encouragements and proper guidance on my research work.

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11. http://t2.htm


Spatial Structure of Residential Land Use: A Case Study of Tahan, Sanmyo and Thazin Wards, Kalaymyo

Win Shwe

ABSTRACT

Residential land use is mainly depended on the physical, economic, and social factors. This study aims to present the residential area in three selected wards of Kalaymyo. First the study identified the spatial and temporal variation of residential land use among the wards. It involves mainly a comprehensive review of secondary source materials such as data of population, household, and house. The comparative situation of the wards were viewed by lorenz curve and location quotient. This paper is studied the spatial distribution pattern of residential land use and house types from the geographical point of view.

INTRODUCTION

Kalaymyo is located on the southwestern part of Sagaing Region. It lies between latitudes 23° 11' N and 23° 35' N and between longitudes 94° 1' E to 94° 2' 15" E. Among the 19 wards of Kalaymyo, three wards Tahan, Sanmyo and Thazin are studied for the residential land use. The reason of choosing this title is that the geography students should know the spatial structure of residential land use of their region. This paper has the following contribution to the knowledge; (1) the spatial and temporal distribution pattern of residential landuse and (2) analyze the house types in the study area.

The chapter (1) describes background of study area, the chapter (2) results, findings and discussion, and conclusion in this paper.

AIM AND OBJECTIVES

This term paper is to make a structural pattern of residential development area. This general objective can be divided into the followings;

1 Lecturer, Department of Geography, Kalay University
1. To study the residential structure spatially.
2. To analyze the residential land use pattern.
3. To compare the characteristics of the residential values to other areas.
4. To understand the changing patterns of residential area.
5. To know the geographical factors influencing upon the growth of town.

MATERIALS AND METHODS

The materials are location map, population data, general land use data, and residential data. The necessary data have been acquired by various means. Firstly, we read previous research paper at the Department of Geography, Kalay University. Then data collection was done at various relevant offices in Kalaymyo. Finally, the collected data are analyzed and illustrated respectively to describe the histogram, Lorenz curve and location quotient methods. The assessment and interpretation are presented by the suitable methods for this term paper.

CHAPTER- 1

BACKGROUND OF STUDY AREA

The study area was selected by the three wards in Kalaymyo. The residential landuse of Tahan, Sanmyo, and Thazin wards are emphasized by studying for the research paper. The topographic surface of Kalaymyo is surrounded by the hills, mountain ranges and rugged terrain. It is located on the Kalay plain between the Chin Hills and Ponthaung. Panyartaung. It is deposited by the Myitthar, Manipur and Neyinzara rivers. Therefore, the new expended areas of the town are controlled by relief features. The present study area of Kalaymyo is 2.22 square miles or 1422.39 acres. It is bounded on the north by Natgyi Kone village tract, on the south by Boggyoke Road on the west by Kyoetthonebin ward and on the east by Chanmyaeang Si ward. It is roughly in rectangular shape. The real extent is rapidly grown due to the extension of new wards of residential area in the year, after 1994.

According to the Koppen’s Climatic Classification, Kalaymyo enjoys tropical monsoon type of climate. The Tropic of Cancer passess through near the Yazagyo in
the northern part of Kalaymyo. It is located on the junction of transportation and communication network. As it is situated at the trade routes leading to India in the north, it serves for the import goods. Besides, it was engaged in the exchange of goods from southern and northern Chin State, Monywa, Mandalay and Gangaw. See Table (1) and Figure (1).

Table (1) The study Area of wards in Kalaymyo.

<table>
<thead>
<tr>
<th>No</th>
<th>Wards</th>
<th>Areas</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Acres</td>
<td>Sq miles</td>
</tr>
<tr>
<td>1</td>
<td>Tanhan</td>
<td>487.98</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Sanmyo</td>
<td>580.09</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Thazin</td>
<td>354.32</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1422.39</td>
<td>2.22</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Administrative Department data

CHAPTER- 2

RESULTS, FINDINGS AND DISCUSSION

2.1 Spatial and Temporal Variation Pattern of Residential Landuse

According to 2011-2012 data, the population density of Kalaymyo is 20 persons per acre. Population densities are respectively 18 persons per acre in Tahan ward, 12 persons per acre in Thazin ward and 10 persons per acre in Sanmyo ward. Among them Tanhan ward is the highest density of population and Sanmyo ward is the least density of population. See Table (2).
Fig. (1) Location Map of the Study Area
In the 2011-2012 data, the household densities are respectively 4 household per acre in Tanhan ward, 2 household per acre in Thazin ward and in Sanmyo. Tanhan ward has the highest density of household.

According to 2011-2012, the house densities are 3 houses per acre at Tanhan and Thazin wards. Sanmyo ward has the least density of 2 houses per acres. Out of total acres of 14708.82 acres of Kalaymyo, residential lands cover about 6634.33 acres amounting to 45.10 percent of the town. Tanhan ward has a residential land area of 387.99 acres, composing about 2.64 percent of the town total lands. Sanmyo ward has a residential land area of 417.09 acres, composing about 2.84 percent of the whole town lands. It is the largest residential land in the town. Thazin ward has a residential land area of 354.32 acres, composing about 2.41 percent of the total town lands. It is the lowest number of residential lands.

Therefore, it can be seen that, residential area forms the largest land use component in the inhabited area of a town. The percentage of residential area depends upon the function of a town. It makes significant impact on overall appearance of the town and its urban form.

Table 2. Population Density of study area (in Kalaymyo)

<table>
<thead>
<tr>
<th>No</th>
<th>Wards</th>
<th>Total Area (Acres)</th>
<th>Total Population</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tanhan</td>
<td>487.98</td>
<td>8963</td>
<td>18.37</td>
</tr>
<tr>
<td>2</td>
<td>Sanmyo</td>
<td>580.09</td>
<td>5882</td>
<td>10.14</td>
</tr>
<tr>
<td>3</td>
<td>Thazin</td>
<td>354.32</td>
<td>4085</td>
<td>11.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14708.82*</td>
<td>289330*</td>
<td>19.67</td>
</tr>
</tbody>
</table>

* Total number of area and Population of Kalaymyo.

Source: Administrative Department data
**Household Density of study area.**

<table>
<thead>
<tr>
<th>No</th>
<th>Wards</th>
<th>Total Area (Acres)</th>
<th>Total Household</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tanhan</td>
<td>487.98</td>
<td>1841</td>
<td>3.77</td>
</tr>
<tr>
<td>2</td>
<td>Sanmyo</td>
<td>580.09</td>
<td>1230</td>
<td>2.23</td>
</tr>
<tr>
<td>3</td>
<td>Thazin</td>
<td>354.32</td>
<td>789</td>
<td>2.71</td>
</tr>
</tbody>
</table>

Source: Administrative Department data

**House Density of study area**

<table>
<thead>
<tr>
<th>No</th>
<th>Wards</th>
<th>Total Area (Acres)</th>
<th>Total Houses</th>
<th>Density</th>
</tr>
</thead>
<tbody>
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<td>1</td>
<td>Tanhan</td>
<td>487.98</td>
<td>1679</td>
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</tr>
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<td>2</td>
<td>Sanmyo</td>
<td>580.09</td>
<td>1199</td>
<td>2.07</td>
</tr>
<tr>
<td>3</td>
<td>Thazin</td>
<td>354.32</td>
<td>763</td>
<td>2.15</td>
</tr>
</tbody>
</table>

Source: Administrative Department data

**Residential land use of study area**

<table>
<thead>
<tr>
<th>No</th>
<th>Wards</th>
<th>Wards Area (Acres)</th>
<th>Residential Area (Acres)</th>
<th>Residential percent of Total Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tanhan</td>
<td>487.98</td>
<td>387.99</td>
<td>2.64</td>
</tr>
<tr>
<td>2</td>
<td>Sanmyo</td>
<td>580.09</td>
<td>417.09</td>
<td>2.84</td>
</tr>
<tr>
<td>3</td>
<td>Thazin</td>
<td>354.32</td>
<td>354.32</td>
<td>2.41</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14708.82*</td>
<td>6634.33*</td>
<td></td>
</tr>
</tbody>
</table>

*Total number of Area and Residential Area of Kalaymyo.

Source: Administrative Department data
2.2 Analysis of Residential land use by House Types

Residential land use is analyzed in terms of house types in the study area. They are brick-house, brick-walled wooden house, wooden house and bamboo house. Total residential dwellings of Kalaymyo amount to 18791 houses. Among the 19 wards of Kalaymyo, three wards Tanhan, Sanmyo and Thazin were taken for the distribution of house types. Table (3) shows the status of different residential dwellings among the wards. It can be seen that at Tanhan ward has the maximum number of brick houses of the whole town. In the distribution of brick house Kalaymyo has a total of 1791 brick houses of which 297 brick houses are found in Tanhan ward, which represents the 16.58 percent of the total houses. Thazin ward contains the minimum number of brick houses, which is only 4.97 percentage of the study area.

In the distribution of brick-walled wooden houses, there are 7925 houses of such type in Kalaymyo of which 1240 houses are Tahan ward, constituting 15.65 percent of the total brick-walled wooden houses of town. The minimum number of brick-walled wooden houses is Thazin ward where only 4.59 percent of the total brick-walled wooden houses of town.

In the distribution of wooden houses, there are 7165 wooden houses in the whole town of which 662 houses is Tanhan ward, comprising 9.24 percent of the total wooden houses in town. Thazin ward occurs only 3.52 percent of the least number of wooden houses in the whole town.

In the distribution of bamboo houses, there are altogether 2010 houses in town of which 82 are Tanhan ward, representing 4.08 percent of the total bamboo houses is situated in Sanmyo where there occurs only 2.44 percent of the total bamboo houses of the town (See Figure 2).

Table (3) Houses type by the study Area.

<table>
<thead>
<tr>
<th>No</th>
<th>Wards</th>
<th>Brick houses</th>
<th>Brick-walled wooden houses</th>
<th>Wooden houses</th>
<th>Bamboo houses</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>%</td>
<td>No</td>
<td>%</td>
<td>No</td>
</tr>
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<td>16.58</td>
<td>1240</td>
<td>15.65</td>
<td>662</td>
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</table>
Table (4) Lorenz curve for Residential land use

<table>
<thead>
<tr>
<th>No</th>
<th>Wards</th>
<th>Residential X</th>
<th>Ward Area Y</th>
<th>X%</th>
<th>Y %</th>
<th>X/Y</th>
<th>Cumulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X%</td>
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<td>417.07</td>
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<td>354.32</td>
<td>30.56</td>
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<td>99.99</td>
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<td></td>
<td></td>
<td>1159.40</td>
<td>1422.39</td>
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</tr>
</tbody>
</table>

Source: Administrative Department data
Table (5) Lorenz curve for Brick Houses by the Study Area.

<table>
<thead>
<tr>
<th>No</th>
<th>Wards</th>
<th>Brick houses X</th>
<th>Total Building Y</th>
<th>X%</th>
<th>Y %</th>
<th>X/Y</th>
<th>Cumulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X %</td>
</tr>
<tr>
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<td>Tanhan</td>
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<tr>
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<td>25.76</td>
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<td>0.12</td>
<td>42.88</td>
</tr>
</tbody>
</table>

Source: Administrative Department data
Table (6) Lorenz Curve for Wooden Houses by the Study Area.

<table>
<thead>
<tr>
<th>No</th>
<th>Wards</th>
<th>Wooden houses X</th>
<th>Total Building Y</th>
<th>X%</th>
<th>Y %</th>
<th>X/Y</th>
<th>Cumulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td>X %</td>
</tr>
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</table>

Source: Administrative Department data

Figure (4) Distribution Pattern of Brick Houses in Study Area
Table (7) Lorenz Curve for Brick-Walled Wooden Houses by the Study Area.

<table>
<thead>
<tr>
<th>No</th>
<th>Wards</th>
<th>Brick – Walled Woodenhouses X</th>
<th>Total Building Y</th>
<th>X%</th>
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<th>X/Y</th>
<th>Cumulation</th>
</tr>
</thead>
<tbody>
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<td>X%</td>
<td>Y%</td>
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</tr>
</tbody>
</table>

Source: Administrative Department data

Figure (5) Distribution Pattern of Wooden Houses in Study Area
Figure (6) Distribution Pattern of Brick-walled Wooden Houses in Study Area

Table (8) Lorenz Curve for Bamboo Houses by the Study Area.

<table>
<thead>
<tr>
<th>No</th>
<th>Wards</th>
<th>Bamboo houses X</th>
<th>Total Building Y</th>
<th>X%</th>
<th>Y%</th>
<th>X/Y</th>
<th>Cumulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Administrative Department data
To analyze the residential land use can be used by the two techniques. First, the Lorenz curve for comparing spatial distribution over space or time; and second, location quotients for examining differences between on observed spatial distribution and a norm or standard. Residential land use by the study area can be analyzed in terms of Lorenz curve. The scattered points on the Lorenz curve represent the distribution of residential land by the study area. If these point scatter along the Z profile, then the distribution will be even and regular. If these point spread along the X and Y axis, then the distribution can be said to be concentrated at a single place. If these points fall between Z profile and X or Y axis, then it can be said that the distribution is irregular.

Therefore, we have studied the distribution of residential land use in the study area. It can be seen that the distribution of residential land use is regular pattern in this area (See Table 4 and Figure 3). Similarly, spatial distribution of brick houses and wooden houses distribution by the study area are found regular as shown by Lorenz curve (See Table 5 and 6, and Figure 4 and 5). Also; the distribution of brick-walled wooden houses, bamboo houses as analyzed by Lorenz curve are found irregular (See Table 7 and 8, and Figure 6 and 7).

Figure (7) Distribution Pattern of Bamboo Houses in Study Area

![Distribution Pattern of Bamboo Houses in Study Area](image-url)
In addition, residential lands use of the study area can be observed that the concentration patterns for individual house type by using the value of location quotient. A location quotient is a way of measuring the relative contribution of one specific area to the whole. The location quotient analysis was done which is useful to achieve information about the relative positions of different wards with respect to a particular houses. It can be seen that the location quotient value of houses are as follow;

L Q <1

A location quotient that is less than 1 suggests that the concentration of a particular bamboo houses in wards are less than that the town as a whole.

L Q = 1.0

The fact that the value of location Quotient is 1 indicates that the concentration of the wooden houses in ward moderates the town as a whole.

L Q>1.0

If the value of location quotient for a particular brick houses and brick-walled wooden in a particular ward exceeds 1, concentration indicates that brick houses and brick-walled wooden houses in the ward exceeds that of the town as a whole. See Table (9).

**Table (9) Location Quotient of Houses by the Study Area.**

<table>
<thead>
<tr>
<th>No</th>
<th>Wards</th>
<th>Brick houses</th>
<th>L Q</th>
<th>Wooden houses</th>
<th>L Q</th>
<th>Brick-walled wooden houses</th>
<th>L Q</th>
<th>Bamboo houses</th>
<th>L Q</th>
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</tr>
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<tr>
<td></td>
<td></td>
<td>*1791</td>
<td></td>
<td>*7065</td>
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<td>*7925</td>
<td></td>
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</tr>
</tbody>
</table>

*Total number of Residential houses of Kalaymyo.

Source: Administrative Department data
According to the location quotient values, the brick houses are high and bamboo houses are low in this region. We observed that in the spatial residential land use of this area, concentration of house types are developed in the wards of urbanization. In the low level, residential area found in the suburban and urban fringes.

The moderate residential areas can be found commercial land use and industrial land use in the study area. The highest level residential areas are observed in the inner core area and the central business district of the study area.

CONCLUSION

In the study area, the development of wards is found in the town. The residential land use pattern of town had changed. Due to the town growth, the former on the outskirts of the wards had become the town area. The urban development of Kalaymyo from the point of view of residential pattern, shows that the residential houses of the wards are found that the concentration and dispersion of types. Among, the study of the 3 wards area, Tanhan ward is the place where business functions converge, high rise buildings concentration.

The project of extending 5 wards to 19 wards had been planned to extent the town area. Thus, the extension of residential land has been observed along the river, rail road and motor road. In Kalaymyo residential area can be extended in the wards, having agricultural land. It has developed depending on trade, economy, transport, and industrialization in Kalay valley. So it is seen that residential lands is a reason for the development of area. Education is also the important reason for increasing residential houses and house hold in the study area. Another reason, the health-care centres are developed in these wards.

ACKNOWLEDGEMENTS

I am greatly indebted to Dr. Than Than Aye, Professor and Head, Department of Geography, University of Kalay for her permission and guidance to do this research paper. I also thank to everybody for their helpful throughout this research.
REFERENCES


Geological Study on Yazagyo Area, Kalay Township

Teza Kyaw¹, Thi Thi Kyaw²

Abstract

The study area is situated on the eastern flank of the Northern Chin Hills, 32 km north of Kalay Township. The area falls the tectonically dominant Western Ophiolite Belt and Naga Hill Line Ophiolite. Pane Chaung Group, the oldest unit of the area, mainly consists of turbidite sandstone-mudstone alternations. The sandstones are mostly of greywacke type which are fine- to coarse-grained, hard and compacted that have load, flute and groove cast. Thinly laminated, fissile black shales are interbedded with these sandstones. Moreover, red and green siliceous mudstone and massive, highly brecciated red chert are present in this group. The Yazagyo Metamorphics constitutes biotite-quartz schist, chlorite schist and marble. The igneous rock units found are ultramafics, plagiogranite and volcanics. The ultramafic rocks are harzburgite and dunite that are partly or wholly altered to serpentinite. The plagiogranite and volcanic rocks are found as dykes cutting across the ultramafic body. Metamorphism affected on the study area is low-grade regional metamorphism due to the formation of low-grade metamorphic minerals such as actinolite and chlorite. The epidote-actinolite-chlorite schist might be metamorphosed from the mafic igneous composition. The biotite-quartz schist might be transformed from quartz-rich pelitic rocks and marble from limestone. Due to similar in lithology, the protolith of the Yazargyo Metamorphics may be the Pane Chaung Group. The igneous rocks in the study area may be interpreted as the mafic-ultramafic stratiform plutonic complex (Layer B), plutonic complex (Layer C) and extrusive volcanic rocks (Layer E) of the ideal ophiolite sequence. Moreover, the rock of Talong Taung is interpreted as the upper part of the large ultramafic body of Mwe Taung. The igneous rocks of the ophiolite are originated at mid-ocean ridge or island-arc that are transported to subduction and emplaced at their present positions during Mesozoic as young as Cretaceous time transported by regional thrust movement.

I. INTRODUCTION

The Yazagyo area is situated on the eastern flank of the Northern Chin Hills, 32 km north of Kalay Township. It is located between latitude 23° 30' N and 23° 33' N, and longitude 94° 04' E and 94° 07' E, lies 1:50000 scale UTM map no. 2394 02 and 2394 03 (Fig. 1).

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² M.Sc student, Department of Geology, Kalay University
The study area falls in the boundary zone of the Western Ranges and Central Myanmar Basin. The Western Ranges of Myanmar underlain by the rock units of thick, mildly deformed, tightly folded and weakly metamorphosed Mesozoic and early Tertiary flysch type deposits, locally associated with ophiolites and metamorphic tectonites (Win Swe, 1980). Generally the eastern part of the Chin Hills in the vicinity of Kalaymyo is built up of east dipping strongly folded sediments of Triassic, Cretaceous and Tertiary. They are faulted towards the east against the ophiolites of the Webula, Bhopi Vum, Mwetaung and Muallup, Talon Taung (Bannert et al., 1985).

The ophiolite belt including the study area falls in the Western Ophiolite Belt of Hla Htay (2002, 2004) and Naga Hill Line of Hutchison (1975, 2007). The contact between the ophiolites and the sediments in the west is tectonic.

The surface exposures of the igneous masses are not contiguous but their tectonic alignment is obvious and suggests contiguity at depth (Ngaw Cin Pau, 1969). In addition to that these ultrabasites are emplaced along a tectonic suture (zone of weakness) probably during Upper Cretaceous to pre-Eocene (Bender, 1983). Smaller basic complexes of the same type occur at intervals and in the same tectonic situation farther south along the eastern flank of the Arakan Yoma as far as the southwestern tip of Myanmar (Brunnschweiler, 1966).

Moreover, the tectonic setting of Myanmar during late Mesozoic was that of a trench-arc system running roughly north and south, with the trench at the present site of the Western Ranges and the arc along the western margin of the Eastern Highland (Win Swe et al., 1972).
II. STRATIGRAPHY

2.1 General Statement

The study area comprises metamorphic rock units (mainly schists), sedimentary rock units (sandstone, shale) and igneous rocks units (mafics and ultramafics). The rock units are generally N-S trending. The geological map of the Yazagyo Area is shown in Fig. (2).

Fig. (1) Location Map of the Study area
2.2 Sedimentary Rock Unit

2.2.1 Pane Chaung Group

The Pane Chaung Group is firstly named by U.N. (1979) for the sediments that consist of a tightly folded and highly deformed succession of Triassic age comprising sandstones, turbidites and mudstones mostly of flysch facies. Flysch type sediments of Pane Chaung Group are well exposed in the eastern and northern parts of the study area.

The Pane Chaung Group mainly consists of turbidite sandstone-mudstone alternations that form the continuous thick and monotonous. The sandstones are mostly greywackes that are fine- to coarse-grained, hard and compact and dark grey colored in fresh surface (Fig. 3). The sandstones are medium-bedded to massive and
weakly graded. Moreover, the sandstone beds dip steeply nearly E. The sandstone of this group comprises the flute, groove and load casts overlying thin black mudstone that provide excellent evidence for the way-up of beds (Fig. 4).

At the Kyaukkyan Taung, the possible contact with the ultramafic rocks and the Pane Chaung Group can be observed. The flute casts, load casts and groove casts in the Pane Chaung Group shows the overturned in nature. Moreover, the minor synclinal folds are well observed in the greywacke sandstones. The coarser-grained turbiditic sandstone frequently consist of clear quartz grains with detrital white mica which are in a dark grey to black slightly lustrous sub-phyllicit ground mass. Veinlets of quartz and calcite are common in these sandstones.

Thinly laminated black shales are hard and compact are interbedded with the greywacke sandstones (Fig. 5). Some of these show philitic in appearance. In weathered surface, they may be friable and buff-color. In some places, red and green color siliceous mudstones are also exposed (Fig. 6). The red color chert are exposed at the Khamauk Taung that lie in the northeastern part of the study area. The cherts are massive type and highly brecciated. The original bedding nature is obscured.

The contact between the Pane Chaung Group and Ultramafic body is demarcated by quartz veins that strike about NE-SW to N-S and dipping steep to the west (Bannert et al., 1982).

**Fossils and Age**

Pane Chaung Group is assigned the Triassic age that is proved by the occurrence of *Halobia* shale near Bassein, Mt. Victoria, and possibly Kalaymyo (Theobald, 1871; Myint Lwin Thein, 1970; Gramann, 1974 in Bannert et al., 1990). Theobald (1871 in Brunschweiler, 1966) reported the occurrence of Triassic fauna in Axial Series of Rakhine Yoma and assigned it to Triassic. Myint Lwin Thein (1970 in Brunschweiler, 1966) reported the occurrence of *Daonell lammeli* in the dark slaty shale exposed at the west of Kalaymyo and assigned it to Triassic. On the basis of stratigraphic position and previous assigned, the Pane Chaung Group of the study area may be assigned as Middle to Upper Triassic age.
2.3 Yazagyo Metamorphic Rock Unit

The Yazagyo Metamorphics are exposed for about 2 km along the Nayinzaya Chaung sections that is NE of the Talon Taung. In the S they are in faulted against serpentinite and in the N and NW they are in contact with strong brecciated flysch (Bannert et al., 1982). The rock units are biotite-quartz-schist, chlorite-schist and marble. These units are hard to differentiate because of intimately mixed nature.

2.3.1 Biotite-Quartz-schist

The rock unit is well exposed near the Yazagyo dam site (1). The rock displays light pink color on fresh surface whereas buff color on weathered surface.
Biotite-quartz schists are fine- to medium-grained, hard and compact, thin to medium foliated that show schistose texture due to parallel alignment of the minerals (Fig. 7).

2.3.2 Chlorite Schist

The chlorite schist units are exposed in the northeastern part of the metamorphic body. These are well foliated and highly weathered (Fig. 8). Weathered surface of rocks show yellowish color whereas the fresh surface are green color. In some place, talc may be present in the chlorite schist due to the feel of slippery. Moreover, shear zone are marked by soft epidote-actinolite-chlorite schist which frequently include rotated boulders of biotite-quartz schist.

2.3.3 Marble

The marble unit is well exposed at Yazagyo dam site (1). This marble is fine- to coarse-grained, white to light bluish grey color on fresh surface, and non-foliated (Fig. 9). In the Nayinzaya chaung, the marble units are present as lenses in the epidote-actinolite-chlorite schist unit (Fig. 10).

2.3.4 Age of Metamorphism

The metamorphism pre-dated deposition of the Paungyi Conglomerate and probably the Campanian olistostromes, but could be pre- or post-Albian (U. N., 1979, technical report. 4)

Fig. (7)  Highly contorted and schistose texture in biotite-quartz schist (N 23° 32' 42.7", E 94° 05' 17.9")

Fig. (8)  Thinly foliated, green colored chlorite-schist (N 23° 32' 56.2", E 94° 05' 53.8")
2.4 Igneous Rock Units

2.4.1 Ultramafic Rock Unit

Nearly half of the study area is occupied by the ultramafic rocks that covers about 6 sq. km. and has N-S elongated shape. The ultramafic rocks form the main Talon Taung and Ayepayar Taung. The ultramafic body can be traced to the W beneath the young sediments of the Nanchiya Chaung and also to the E along the banks of the Neyinzaya Chaung.

The main rock types of the ultramafic rocks are harzburgite, dunite and serpentinite. Most of these rocks are partly or wholly altered to serpentinite.

**Harzburgite**

The harzburgites are well exposed at the center and northern part of the Talon Taung. They are medium- to coarse-grained, grayish green, massive and highly jointed but yellowish brown color on weathered surface (Fig. 11). These rocks constitute mainly olivine and orthopyroxene with minor amount of clinopyroxene. These minerals are more or less altered to serpentine minerals.

**Dunite**

It is well observed at the Ayepayar Taung, SW of the Talong Taung. This rock unit is fine-grained phaneritic rock that constitute wholly of olivine (Fig. 12). This dunite is more fine-grained comparable with the harzburgite. It is dark grey color on
weathered surface and dark green color on freshed surface. In this rock, the disseminated chromite minerals are commonly present.

### 2.4.2 Plagiogranite

The small bodies of plagiogranite trending mainly N-S has been found in the Talon Taung ultramafic bodies. The rocks is exposed as vein-like and about 1 m wide, striking 120° and dipping 60°/NE, in the NE part of the serpentinite on the W bank of the Neyinzaya Chaung. They show yellowish color on weathered surface and light gray to greenish color on fresh surface. The rock contains mainly quartz, plagioclase feldspar, and biotite as minor constituent. Moreover, pyrite ore minerals are disseminated throughout this rock (Fig. 13).

The top of the plutonic complex of the ophiolite sequence is generally composed of coarse- to fine-grained varitextured gabbro, diorite, and plagiogranite (Moores and Twiss, 1995). Thus this plagiogranite may be one of the members of the ophiolite sequence.

### 2.4.3 Volcanic Rock Units

Talon Taung is dissected by volcanic dykes, mainly diabase. These dykes cut through the sediments as well as through the ultrabasic body. They are more than 10 m thick and can be traced by the distance of some tens of meters in some places. The dip of the dyke is nearly vertical; the strike varies from approximately E-W to NNE-SSW.

The diabase is of dark colored and fine-grained. It is composed of plagioclase, up to 20% quartz, some amount of amphibole and relics of clinopyroxene which are altered to chlorite. Aggregates of slightly altered plagioclase and corroded quartz grains are porphyritic nature in the fine grained groundmass of plagioclase and quartz with some epidote.

Some dykes found in the S and E parts consist of up to 80% brecciated volcanic fragments in a fine-grained groundmass (Fig. 14). Quartzite and ultramafic xenoliths are also embedded in the groundmass (Fig. 15). The size of the fragments ranges in diameter from 7-30 cm.
2.4.5 Serpentinite

Among the partly altered serpentinite from harzburgite and dunite, the purely serpentinite body is observed as the highly jointed, sheared type (Fig. 16). This type is the result of tectonic movement. The shear serpentinite is recognized as a fault zone which separates the ultramafic rocks from the metamorphic area. Moreover, the harzburgite and dunite of the ultramafic units are mostly altered to serpentine minerals.

2.4.6 Probable Age

The ultramafic rocks were generated as magmatic rocks in or before the Jurassic (U. N., 1979, technical report 4). In addition, K/Ar radiometric age determination on hornblende within a serpentine boulder derived from the ultrabasic body in the Mu Chaung and Kanpetlet areas indicates the 158±20 Ma (U. N., 1979, technical report 6). Moreover, on the basis of the nature of contact, lack of contact metamorphism, the age of these ultramafic rocks may be intruded in the middle Jurassic.

Fig. (11) Dark green colored, medium to coarse-grained Ultramafic rocks (harzburgite) (N 23° 31' 29.8", E 94° 05' 36.5")

Fig. (12) Dark green colored, fine-grained dunite (N 23° 30' 25.9", E 94° 05' 08.8")
2.5 Mode of Occurrence and Emplacement of Igneous Rock Units

Basal harzburgite is usually considered as residual mantle material from which oceanic basaltic magma was bled (Dickinson, 1972 in Hutchison, 1975).

The plagiogranite may be formed as a final differentiation product of MORB magma (Philpotts, 1990).

The serpentinite probably formed by hydrolysis of harzburgite with water expelled from underlying sediments may have risen diapirically during an episode of extensional tectonics (Mitchell, 1986). Moreover, at the pressure corresponding to depths of a few kilometers, magnesian olivine in continuous contact with a flux of pure H$_2$O is unstable at temperatures below 400°C (William et al., 1982).
The ultramafic rocks were generated as magmatic rock in or before the Jurassic, but emplaced at their present position as cold bodies in the Upper Cretaceous (U. N., 1979, technical report 4). These ultramafic rocks are exposed between the flysch unit to the west and molassic rock unit to the east. They have lack of contact aureoles, however, small amount of talc chlorite schist or green schist can be observed near these bodies especially in the low land area of eastern side.

2.6 Petrogenesis of Metamorphic Rocks

Metamorphism which affected the rock units of the study area is low-grade regional metamorphism. It is marked by the formation of low-grade metamorphic minerals, especially actinolite and chlorite.

The mineral association and relation are studied microscopically and megascopically from the various metamorphic rock units. The forming mineral assemblages are –

- Biotite-quartz
- Epidote-actinolite-chlorite
Based on the above mineral assemblages, the rock units fall in the greenschist facies of biotite zone. The actinolite is the characteristic mineral of greenschist facies (Miyashiro, 1957). According to mineralogical changes in the composition of amphibole, actinolite is the characteristic of the lower temperature facies (Yardley, 1998).

With increase in metamorphic grade to the greenschist facies, basaltic rocks are composed of chlorite, epidote, and actinolite (plus albite and quartz) (Philpotts, 1990).

The protolith of the metamorphic rocks may be mafic igneous rocks as well as the pelitic and carbonate rocks. Epidote-actinolite-chlorite schist may be considered as the transformation of mafic composition because the most characteristic mineral assemblage of the greenschist facies in metabasites is chlorite + albite + epidote + actinolite + quartz (Winter, 2001). The biotite-quartz schist and marble may be metamorphosed from the quartz rich pelitic rocks (mostly siliceous mudstone or chert) and from the limestone, respectively.

Moreover, the above all metamorphic rock units may be similar to the lithologic sequence of the Pane Chaung Group. In addition, these metamorphic rocks were originally sedimented as Triassic flysch (Bannert et al., 2011). So the protolith of the Yazagyo metamorphic may be the Pane Chaung Group.

III. ECONOMIC ASPECT

3.1 Chromite

Chromite mineralizations, connected with the ophiolite ultramafic rocks, are found at the Talon Taung. There are two localities in the Talon Taung area on the W side of the hill as pebble material. The chromite minerals are disseminated as accessory mineral in dunite and harzburgite. The chromite grains are fine- to coarse-grained. Moreover, the chromite minerals are more concentrated in dunite than the harzburgite. Possible origins of the chromite include incongruent partial melting of primitive lherzolitic mantle, or crystal fractionation of basic magma resulting in ultramafic cumulates (Mitchell, 1976).
IV. DISCUSSION

The study area is situated in the Kalay Township, Sagaing Region. It lies the eastern part of Chin Hills and tectonically the Chin-Naga Hill Line Ophiolite of Hutchison (1975; 2007) and the Western Ophiolite Belt of Hla Htay (2002; 2004).

The rock units exposed in the study area are Pane Chaung Group (Middle to Upper Triassic), Igneous rock units including ultramafic rocks, plagiogranite, volcanic rocks and serpentinite (? Late Jurassic), and Yazagyo metamorphic unit (Middle to Upper Cretaceous).

The oldest unit in the Western Ranges, Pane Chaung Group mainly consists of sandstone-mudstone alternations that form the continuous thick and monotonous. The sandstones are mostly greywacke that are fine- to coarse-grained, hard and compact, and dark grey colored in fresh surface. Thinly laminated black shales are hard and compact and fissile in natures that are interbedded with the greywacke sandstone. Moreover, non-fossiliferous red colored chert and siliceous mudstone units are also found in this group. The Pane Chaung Group may be assigned Middle to Upper Triassic in age on the basis of the occurrences of Halobia and Daonell lammeli of the previous researchers.

The Yazagyo metamorphic rock unit constitutes biotite-quartz schist, chlorite schist and marble. The biotite-quartz schist are pink color, hard and foliated, fine- to medium-grained. The chlorite schists are greenish color, highly weathered and well foliated. In some section, talc may be present. Moreover, epidote-actinolite-chlorite schists are present. The marble units are white to light bluish grey and non-foliated. The marble units are lenses in the succession of epidote-actinolite-chlorite schist. The time of metamorphism could be pre- or post-Albian in age (U. N., 1979, technical report 4).

The ultramafic rock units are mainly harzburgite, dunite and serpentinite that are partly or wholly serpentinite. The harzburgite are medium- to coarse-grained, grayish green, massive and highly jointed on fresh surface that are composed of olivine and orthopyroxene with minor amount of clinopyroxene. The dunites are fine-grained phaneritic rock that constitute wholly of olivine. Disseminated chromites are more enrich than in olivine compared with the harzburgite. The plagiogranite lens-shaped bodies trending N-S, compose of quartz, feldspar and minor biotite with
disseminated pyrite ore. Moreover, the volcanic dykes dissected the ultramafic bodies that are composed mafic composition with xenoliths fragments. In addition, pure serpentinite is formed as the sheared type that is marked as the faulted contact. The age of the igneous rocks may be Middle Jurassic.

Metamorphism which affected the rock units of the study area is low-grade regional metamorphism. It is marked by the formation of low-grade metamorphic minerals, especially actinolite and chlorite.

The metamorphic rocks are formed due to low-grade regional metamorphism because of their mineral assemblages display greenschist facies of biotite zone.

The protoliths of the metamorphic rocks may be mafic igneous rocks as well as the pelitic and carbonate rocks. So the protolith of the Yazagyo metamorphic may be the Pane Chaung Group since the all exposed metamorphic rock units may be the same as the lithologic sequence of the Pane Chaung. In addition, these metamorphic rocks were originally sedimented as Triassic flysch (Bannert et al., 2011).

The present study of the ophiolite suite includes harzburgite, dunite, plagiogranite and volcanics. These rocks may be interpreted as the mafic-ultramafic stratiform plutonic complex (Layer B), plutonic complex (Layer C) and extrusive volcanic rocks (Layer E) of the ideal ophiolite sequence (Moores and Twiss, 1995).

Moreover, in the Naga Hills Ophiolite, northeast India, the northern continuation of Chin-Naga Hill ophiolite, the geochemical nature of volcanic rocks show Mid-ocean Ridge Basalt and island-arc basalt (Sengputa et al., 1989). Thus the igneous rocks of the ophiolite suite in the study area are originated at mid-ocean ridge or island-arc that are transported to subduction and emplaced at their present positions during Mesozoic as young as Cretaceous time transported by regional thrust movement.

The essential economic mineral in the study is chromite that occurs throughout the ultramafic igneous rock units especially at the Talon Taung.
ACKNOWLEDGEMENT

I would like to thank Professor Dr. Aung Win Swe, Head of Department of Geology, Kalay University, for his kind of permission to do this research paper. I would like to give my thanks to my colleagues at Department of Geology, Kalay University for their helpful in the field and laboratory work throughout this research work.

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The Coming of Christianity into the Chin Hills

Dr. Yi Yi Shwe

Abstract

This paper attempts to analyze and discuss the coming of Christianity into the Chin Hills, especially its northern parts. It also tries to examine the effects of the coming of Christianity into the Chin Hills, especially its effects on the socio-economic life of the Chin tribes, the results of Christian Missionaries' efforts on the development of Chin people. The paper also provides a brief analysis on how and why the coming of Christianity played a vital part in the modernization of the far-backward local hills tribes. It also attempts to evaluate how the Christianity provided the Chin people with a new world view and value system, and what extent to play to modernize their social structures and social status.

THE COMING OF CHRISTIANITY INTO THE CHIN HILLS

The land in the Chin Hills before the British occupation was all held by the Chin chiefs. The administration of the chiefs was mainly concerned with the maintenance of law and order in their community and taxation. Prior to the British annexation in 1896, the Chin people were absolutely independent people. The local chiefs exercised unbounded power. Surrounding kingdoms like Myanmar, Bangladesh, and India (Assam) never conquered the Chin people and their land. As a result, Buddhism, Islam and Hinduism never reached the Chins.

The Chin people formed a collection of tribes belonging to one and the same. Animism was the prevailing religion. The Chin people were exceedingly superstitious, set great store by omens, and had a great belief in the efficacy of sacrifice. They worshipped spirits and devils. They believed that spirits and devils were able to trouble them in every conceivable manner and they propitiated them

1. Professor & Head of Department, History Department, Kalay University
2. N.E Parry, Lushai Custom, Shillong, Printed at the Assam Government Press, 1928, p.3
with sacrifices.\(^1\) The Chin animists believed that sickness was caused by evil spirits or nats; practically the only means of averting or curing sickness was performing the appropriate sacrifices and ceremonies to them.\(^2\)

After the promulgation of the Chin Hills Regulation, 1896, the British government paved the way for the coming of Christianity into the Chin Hills. The British colonial officer Captain Dury invited the Carsons to come to their newly occupied colony and work in the Chin Hills in what is now known as the Chin State in Myanmar. As the request of Captain Dury, Arthur Carson and his wife Laura Carson were appointed as the first missionaries to the Chins by the American Baptist Mission. The Carsons were from Columbus City, Iowa, United States.\(^3\) They arrived in Haka on 15 March 1899.\(^4\)

The Chins did not know at first the difference between the British soldiers and American Christian Missionaries. The Carsons were often mistaken for agents of the British soldiers. Therefore, the Carsons could not at first find a local teacher to teach them the Chin language. But it was an Indian called Mr. Joseph who taught them the Chin (Chin) dialect. Much later, two Chins, Chia Khawm and Tum Kir, became their teachers.\(^5\) In order to provide education, the American Baptist Mission established a Mission School at Haka in Northern Chin Hills in 1899.\(^6\)

From 1899 to 1907, the American Baptist Mission claimed to have converted thirty-six Chins from Animism to Christianity. Christianity resulted in the disappearance of inter-tribal or inter-village feuds in Chin Hills.\(^7\) Before the coming of Christianity, there were inter-village feuds which split the people and resulted in a difference of tongues, a variety of customs, and a diversity of living.\(^8\) The Chins never

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1 *Imperial Gazetteer*, Rangoon, Government Printing, 1906, pp.78-80
5 Sakhong, *Chin Identity*, p.125
7 *Report in the Administration of the Chin Hills for the year 1906-07*, Rangoon, Government Printing, December 1907, pp.2-3 (Hereafter cited as RAC, 1906-07)
never treated their enemies cruelly, although the blood feud was the general Chin method of avenging murder.¹

The introduction of Christianity made the Chins more inclined to take advantage of the medical services provided by the British government. There was also a greater willingness to provide labour for road work and the transport of supplies as well as an increased submission of distributes for settlement to the government officers.² Under the management of the British government, the Chin people were employed in carrying the mails, and maintaining the government roads, and as forest rangers, telegraph linesmen, vaccinators, ward servants, interpreters, peons, domestic servants, etc. They were also enlisted for service in the Civil Police, and proposals for enlisting them in the Military Police during the year 1907-08.³

As the Carsons requested the Home Board to send another missionary couple to the Chin Hills, the first medical missionary Dr. East, with his wife Emily Johnson, arrived in Haka on 21 March 1902.⁴ The American Baptist Mission erected a mission hospital at Haka in 1906. In addition to the dispensary and operating room there was accommodation in the wards for twenty-two patients. During the season of 1906-07, the number of Chins treated was 36,935. The next year, the accommodation in the civil hospital at Falam was improved and made more comfortable. The increase in the attendance at hospitals indicated a feeling of growing confidence among the tribes.⁵ A total of 4,447 cases were treated by Dr. East in the Mission Hospital at Haka during the season of 1908-09. In fact, before the coming of Christian missionaries, the Chin people did not rely on modern medical treatment because they believed that diseases were caused by witches and evil spirits. The entry of Christianity had an unsettling effect on the life of the Chins who had previously been involved with various sacrifices to the evil spirits.⁶

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² *Report on the Administration of Burma for the year 1900-01*, Part II, Rangoon, Government Printing, 1901, para-9, p.3
⁴ Sakhong, *Chin Identity*, pp.126-127
⁵ *RAC, 1906-07*, p.7
⁶ *RAC, 1922*, p.2
The undertaking of health activities by the British and Christian missionaries brought about some improvement in the condition of public health which became better than that before British rule. In 1910, the American Baptist Chin Mission suffered a major setback in its medical mission because Dr. East suffered a severe heart attack. Therefore, Dr. John Gustav, a medical missionary, came to the Chin Hills in the same year in order to replace Dr. East at the Haka mission hospital. Apart from the work at the hospital, the Christian missionaries gave medical treatment to patients in the villages which they visited.¹

In 1935, the offer of the American Baptist Mission to lend their hospital buildings at Haka free of rent for a period of thirty-five years for use as a civil hospital was accepted by the British government. Besides, Htual Neng, a contractor of Tiddim, offered to build a small additional ward for the hospital at Tiddim. This generous offer was also accepted by the British government.² However, one of the great obstacles in the way of the growth of popularity of medical treatment was the fact that few of the medical staff remained long enough or were sufficient interested to learn the language, without which it was difficult to gain the confidence of the people. This obstacle would be removed if at least some of the posts could be filled by Chins. Up to 1940, however, no Chin from the Falam subdivision had qualified.³

In June 1900, the Carsons opened a Mission School in Haka with Saya San Win as the teacher. Unfortunately, the Mission School was closed due to a piece of wrong information given by Sergeant that a Buddhist School would give them food and clothes if they would attend the Buddhist school although no such school existed at that time. The Mission School at Haka was reopened in June 1901 with seven boys.⁴ When the American Baptist Mission opened several new village schools, one of the great obstacles was the use of Myanmar as the medium of instruction.⁵ In 1923, the Mission School at Haka was raised to a full middle school. But the Mission

¹ Sakhong, Chin Identity, p. 145
⁴ John, History Chin Mission, Vol. I, p.64
⁵ Report on the Administration of Burma for the year 1921-22, Part II, Rangoon, Government Printing, 1923, p.46
suffered a serious loss when its school building and all equipment at Haka were burnt down.¹

Until 1920, there was no Government School in Haka, only an American Baptist Mission School and one primary school in Zokhua. In 1921, a school for the sons of chiefs was established at Haka by the British government.² In 1925, all the mission schools in Haka subdivision were taken over by the British government. In 1929, the Haka Middle School was reopened on a self-help basis at the place of present Vawmthu Mawng Sports Ground. There were four teachers and three hundred students in the school. In 1947, it was nationalized by the government and upgraded to a high school shifted to the place of the present No.1, State High School, Haka.³

The British government also founded a primary school at Haka for the sons and daughters of the chiefs, but commoners were not allowed to attend this school. Some youths did not have permission to attend the school though they wanted to. It was due to the limitation of the student population. The educational policy of the British government was to produce only a few educated persons who would serve their administration. The schools founded in the Chin Hills were vernacular schools teaching in the Myanmar language. In 1913, the Haka Mission Primary School which taught in the Myanmar language was upgraded to a middle school, but it was degraded to a primary school teaching in the Chin language in 1925.⁴

The first village school in the Tiddim subdivision owned their inception to the American Baptist Mission, but in 1925 all such mission schools were taken over by the British Government. In addition other Government village schools were opened some of which, notably Lennacot and Haicin in the Kamhau tract and Suangphei village school, had only short terms of life and were ultimately closed down as it was realised that the people in these areas were not ready to appreciate the advantages of education.⁵

¹ Report on the Administration of the Chin Hills for the year ended the 39th June 1923, Rangoon, Government Printing, 1923, p.13
² Report on the administration of the Chin Hills for the year ended the 30th June 1921, Rangoon, Government Printing, 1921, p.8
⁴ Van Tin Lian, “History of Haka Township”, pp.58-60
⁵ File No.13, Conferences (1937-1941), p.133
Not only the British government but the American British Mission also started several schools in Northern Chin Hills and did splendid work. An excellent attempt at reducing the Haka dialect to writing was made by the American Baptist Missionaries. In view of the fact that almost everyone agreed to the use of the Roman character as more suitable than the use of Myanmar, there seemed to be no need for a conference to settle the subject.¹

The Copes, American Christian Missionaries, arrived in Haka on 12 December 1908. Rev. Cope learned Haka, Laizo (Falam) and Kamhau (Tiddim) dialects while they were in Haka. In fact, he was the one who transcribed the Kamhau and Laizo dialects into a written form.² In 1924, Dr. Cope became the Inspector of Schools when the British government took over all the mission schools according to the new arrangement of cooperation between the British government and the American Baptist Mission. In his position as the Inspector of the Schools, Dr. Cope produced thirty-five textbooks for primary schools in the Haka and Kamhau dialects.³ The programme of Christian Mission Schools continued and more Kayin teachers came up to help the American Missionaries.⁴ In the Northern Chin Hills, several schools were opened when the chiefs took an interest.⁵ There was a great improvement in education among among the Chins as a result of the special attention paid to the Deputy Commissioner, Colonel Burne, ably seconded by the Rev. Cope, Honorary Inspector of Schools in the Chin Hills.⁶

In the summer of 1935, the American Baptist Mission withdrew completely from the general education mission, except for Dr. Cope who continued as the Inspector of Schools until his death in 1938. It was due to the fact that the British government issued a new order which prohibited daily prayers and chapel service in government schools.⁷

¹ RAC, 1922, p.2
² Sakhong, Chin Identity, pp.144-145
³ Ibid, pp.166-171
⁴ Ibid, p.245
⁷ Sakhong, Chin Identity, p.174
In conclusion, Christianity could provided the Chin people with a new world view and value system, which better equipped them to cope with the new challenges to modernization of their social structure and social status. So much so that the Christian Missionaries played an important role not just in religious life of the Chins but also their socio-economic life.

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EXISTENCE, UNIQUENESS AND REPRESENTATION
OF SOLUTIONS FOR A NONLINEAR DIFFERENCE EQUATION

Yee Tint

Abstract

This paper is concerned with a nonlinear difference equation in complex variables. We give some definitions and results for complex-valued functions and study the existence and uniqueness of meromorphic solutions for a particular difference equation. The solution can be represented in only two ways. We present the condition under which the solution can be represented in one of these two ways.

1. Some Basic Definitions in Complex Variables

Let U be an open set in \( \mathbb{C} \) and let \( f: U \to \mathbb{C} \) be a complex-valued function. For \( a \in \mathbb{C} \) and \( R > 0 \), we write

\[
B(a, R) = \{ z \mid |z - a| < R \} \quad \text{and} \quad B^*(a, R) = \{ z \mid 0 < |z - a| < R \}.
\]

If \( f \) is differentiable at all points of \( U \), we say that \( f \) is holomorphic in \( U \). A function which is defined and holomorphic everywhere on \( \mathbb{C} \) is called an entire function.

Definition 1.1.

A function \( f \) is said to have an isolated singularity at \( a \in \mathbb{C} \) if there is \( R > 0 \) such that \( B^*(a, R) \subset U \) and \( f \) is holomorphic on \( B^*(a, R) \) but not holomorphic on \( B(a, R) \).

The point \( a \) may or may not belong to \( U \). Thus \( a \) is an isolated singularity of \( f \) if and only if either \( f \) is undefined at \( a \) or it is defined at \( a \) but is not differentiable at \( a \).

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Definition 1.2.

A function $f$ is said to have a removable singularity at $a \in \mathbb{C}$ if there is $R > 0$ such that $B^*(a, R) \subseteq U$, $f$ is holomorphic on $B^*(a, R)$ and if there is a holomorphic function $g$ on $B(a, R)$ which coincides with $f$ on $B^*(a, R)$.

A holomorphic function $f$ has a removable singularity at $a$ if and only if $\lim_{z \to a} (z-a)f(z) = 0$. A point $a$ is a removable singularity if and only if $\lim_{z \to a} f(z) = c$.

Definition 1.3

A function $f$ is said to have a pole at $a \in \mathbb{C}$ if there is $R > 0$ such that $f$ is holomorphic on $B^*(a, R)$ and if $\lim_{z \to a} f(z) = \infty$.

A function $f$ has a pole at $a$ if and only if there exists a positive integer $n$ and a holomorphic function $h$ on $B(a, R)$ with $h(a) \neq 0$ such that $f(z) = \frac{h(z)}{(z-a)^n}$ for $z \in B^*(a, R)$. A point $a$ is a pole if and only if $\lim_{z \to a} ((z-a)^nf(z)) = c$ for a positive integer $n$.

Definition 1.4.

An isolated singularity of a function $f$ is said to be an essential singularity if it is neither a removable singularity nor a pole.

A point $a$ will be an essential singularity of $f$ if and only if $\lim_{z \to a} ((z-a)^nf(z))$ does not exist for any integer $n \geq 0$.

Definition 1.5.

A function $f$ on $U$ is said to be meromorphic on $U$ if it has at most removable singularities or poles in $U$ but no essential singularity.
For example, \( f(z) = \frac{z^2 - a^2}{z - a} \) is meromorphic on \( \mathbb{C} \) with a removable singularity at \( a \). Similarly, \( f(z) = \frac{1}{\sin z} \) is meromorphic on \( \mathbb{C} \) with poles at \( n\pi, n = 0, \pm 1, \pm 2, \ldots \).

The function \( f(z) = e^z \) is not meromorphic.

A holomorphic function is meromorphic. If a meromorphic function has a removable singularity at a point, by assigning a suitable value to the function there, it can be assumed to be holomorphic at that point.

Given a meromorphic function \( f \), the zeros of \( f \) are the poles of the function \( \frac{1}{f} \) and vice-versa. And \( \frac{1}{f} \) has no other singularities.

**Definition 1.6.**

An analytic function \( g(z) \) in \( U \) is said to be univalent if \( g(z_1) = g(z_2) \) only for \( z_1 = z_2 \).

**Definition 1.7.**

Let \( \mathcal{F} \) denote a family of functions \( f \), defined in a fixed region \( U \) of the complex plane. Family \( \mathcal{F} \) is said to be normal in \( U \) if every sequence \( \{f_n\} \) of functions in \( \mathcal{F} \) contains a subsequence which converges uniformly on every compact subset of \( U \).

**Rouche’ theorem 1.8.**

Let \( f \) and \( g \) be meromorphic on \( U \) and suppose \( \text{cl} \ B(a, R) \subset U \) for some \( a \) and \( R > 0 \). Suppose that \( f \) and \( g \) have no pole or zero on the circle \( C \) at \( a \) of radius \( R \) and
\[ |f(z) - g(z)| < |g(z)| \text{ for } z \in \mathbb{C}. \text{ Then } Z_f - P_f = Z_g - P_g, \text{ where } Z_f\text{ is the number of zeros of } f \text{ inside } \mathbb{C}, \text{ each counted as often as its multiplicity, and } P_f \text{ number of poles inside } \mathbb{C}, \text{ similarly counted and } Z_g \text{and } P_g \text{ are defined analogously.}

2. A Nonlinear Difference Equation

Let \( w = w(z) \) be a function from \( \mathbb{C} \) to \( \mathbb{C} \). We consider a nonlinear difference equation

\[
w(z+1) = w(z) + 1 + \frac{\lambda}{w(z)},
\]

where \( \lambda \in \mathbb{C} \) is a given constant.

Let \( \phi(z) \) be the meromorphic solution of (1) such that \( \phi(z) \) is holomorphic in a domain

\[
D(R, \beta) = \{ z \mid |z| > R, |\arg z - \pi| < \frac{\pi}{2} - \beta \} \cup \{ z \mid |\text{Im}(z e^{i\beta})| > R \}
\]

and

\[
\phi(z) \sim z \left( 1 + \sum_{j=1}^{k} \frac{p_{jk} (\log z)^j}{z^{jk}} \right), \text{ as } z \to \infty \text{ in } D(R, \beta),
\]

where \( \beta, 0 < \beta < \frac{\pi}{2} \), and \( p_{1,0} \) can be prescribed arbitrarily, and \( R \) is a positive number depending on \( \beta \) and \( p_{1,0} \). The existence and uniqueness of such solution \( \phi(z) \) are proved in [6] and some properties of \( \phi(z) \) are studied in [6],[9].

Let \( \tau(z) \) be any entire periodic function with the period 1. Then

\[
w(z) = \phi(z + \tau(z)),
\]

is easily seen to be also a meromorphic solution of (1).

It is the case to see that a meromorphic solution \( w(z) \) of the form (4) satisfies the condition

\[
\text{Re } w(x + iy) \to -\infty \text{ as } x \to -\infty
\]
for each \( y, -\infty < y < \infty \). Now we put

\[
b = e^a = 1 - \frac{1}{\lambda}, \quad -\pi < \text{Im} a \leq \pi
\]

and consider the equation

\[
v(b\zeta) = v(\zeta) + 1 + \frac{\lambda}{v(\zeta)}. \quad (6)
\]

To obtain a formal solution of this equation, we substitute \( v(\zeta) = -\lambda + \sum_{j=1}^{\infty} \alpha_j \zeta^j \) into (6) and equate the coefficients on both sides.

Then we have

\[
\frac{b - b^j}{b - 1} \alpha_j = \sum_{m=1}^{j-1} \alpha_m (b^m - 1) \alpha_{j-m}, \quad (7)
\]

where \( \alpha_j, j \geq 2 \), are determined uniquely when \( \alpha_1 \) is prescribed arbitrarily and it is supposed that \( b^j \neq 1 \) for any \( j \geq 1 \).

**Proposition 2.1.**

Suppose \( |b| = |1 - \frac{1}{\lambda}| > 1 \). Let \( \alpha_1 \) be an arbitrary constant. Then, (6) has the unique solution \( v(\zeta) \) which is holomorphic at \( \zeta = 0 \) and \( v'(0) = \alpha_1 \).

**Proof**

See [10].

\( \square \)

**Theorem 2.2.**

Suppose \( \text{Re } a > 0 \), i.e., \( |b| = |1 - \frac{1}{\lambda}| > 1 \). Then there is a meromorphic solution \( \omega(z) \) of (1) such that

\[
\omega(z) \text{ is holomorphic in } S_{(a,R)} \quad (8)
\]
and

\[ \omega(z) = -\lambda + \sum_{j=1}^{\infty} \alpha_j e^{\alpha_j z} \] in \( S(\alpha, R) \)

(9)

where \( S(\alpha, R) = \{ z \mid \text{Re}(az) < -\log R \} \), \( \alpha_j \) can be described arbitrarily, and \( R > 0 \) depends on \( \alpha_1 \). The solution \( \omega(z) \) is uniquely determined if \( \alpha_1 \) is given. We have

\[ \omega(z) = \omega(z + \frac{2k\pi i}{a}) \] for any integer \( k \),

(10)

whence \( \omega \) is a function of \( \zeta = e^{\alpha z} \), and we can write

\[ \omega(z) = \psi(e^{\alpha z}) \]

(11)

with a function \( \psi(\zeta) \) meromorphic in \( |\zeta| < \infty \).

**Proof**

See [10].

\( \square \)

**Remark 2.3.**

From the procedure determining \( \alpha_j \), we see that, if \( \alpha_j = 0 \), then \( \alpha_j = 0 \) for all \( j \geq 2 \). Thus, the trivial solution \( w(z) = -\lambda \) is included in this theorem.

**Corollary 2.4.**

When \( \left| 1 - \frac{1}{\lambda} \right| > 1 \), the solution \( \omega(z) \) in Theorem 2.2 can not be represented in the form (4).

Since \( \omega \) is a function of \( e^{\alpha z} \), the function

\[ w(z) = \omega(z + \frac{1}{a} \log \tau(z)) = \psi(\tau(z) e^{\alpha z}), \]

(12)
where $\tau(z)$ is an entire periodic function with the period 1 is a meromorphic function. We can show that $w(z)$ of (12) is also a solution of (1). Here, of course, we suppose that $\left| 1 - \frac{1}{\lambda} \right| > 1$.

### 3. Some Lemmas

We use the following notations:

\begin{align}
L(y;K) &= \{ z = x + iy \mid -\infty < x \leq K \} \\
P_{\delta}(y;K) &= \{ z = x + iy \mid -\infty < x \leq K, \; |y - y_0| \leq \delta \} \\
Q_{\delta}(y;c) &= \{ z = x + iy \mid c \leq x \leq c + 2, \; |y - y_0| \leq \delta \} \\
S_{\delta}(y_0) &= \{ z = x + iy \mid -\infty < x < \infty, \; |y - y_0| < \delta \}
\end{align}

where $\delta > 0$. For a number $d > 0$, we put

\[
D(R,\beta;d) = D(R,\beta) \cap \{ z \mid |z| > d \}
\]

where $D(R,\beta)$ is the domain defined in (2).

Let $w(z)$ be meromorphic solution of (1). We put

\[
Y_{np} = \{ y \mid \exists K(y) \in \mathbb{R} \text{ such that } w(z) \text{ has no poles on the line } L(y;K(y)) \}
\]

(17)

Clearly, we have the following dichotomy for $w(z)$:

- either

  \[
  \text{there is a } y_0 \in Y_{np}, \limsup_{x \to -\infty} |w(x + iy_0)| = \infty
  \]

  (18)

- or

  \[
  \text{for any } y_0 \in Y_{np}, \limsup_{x \to -\infty} |w(x + iy_0)| < \infty.
  \]

(19)

**Lemma 3.1.**

Let $\phi(z)$ be the meromorphic solution of (1), satisfying (3). Let $\beta < \frac{\pi}{4}$. Then we can take a number $d > \max \left\{ \sqrt{2}R, 1 \right\}$ such that
\[
\left| \frac{d\phi(z)}{dz} - 1 \right| < \frac{1}{2} \quad \text{for} \quad z \in D(R, \beta; d),
\]
(20)

\[
\left| \frac{\phi(z)}{z} - 1 \right| < \frac{1}{6} \quad \text{for} \quad z \in D(R, \beta; d),
\]
(21)

\[
\phi(z) \text{ is univalent in } D(R, \beta; d)
\]
(22)

and

\[
\xi = \phi(z) \text{ takes every value } \xi, \Re \xi < -4d, \text{ in } D(R, \beta; d).
\]
(23)

**Proof**

See [10].

\[\square\]

**Lemma 3.2.**

Let

\[
G(z) = z + 1 + \frac{\lambda}{z}
\]
(24)

and write \(G^2(z) = G(G(z)), \ G^3(z) = G(G(G(z))), \ldots\).

Put, for \(n = 1, 2, 3, \ldots\),

\[
q_n(z) = G^n(z) - z - n - g_n(z)
\]
(25)

where

\[
g_n(z) = \sum_{j=0}^{n-1} \frac{\lambda}{z + j}
\]
(26)

Then we obtain for \(z \in D^+(\bar{R}, \beta) = \{z \mid \Re z > 0, -z \in D(\bar{R}, \beta)\},\)

\[
|q_n(z)| \leq M \sum_{m=0}^{n-1} \frac{|g_{m+1}(z)| + 1}{|z + m|^2},
\]
(27)

where \(M\) is a positive constant, provided \(\bar{R}\) is sufficiently large.

**Proof**

See [5].

\[\square\]

From now on we will assume that \(w(z)\) is a meromorphic solution of (1).
Lemma 3.3.

Let \( y_0 \in Y_{np} \) where \( Y_{np} \) is the set defined in (17). Then, there is a number \( K(y_0) \) such that

\[
\Re w(x + iy_0) < \bar{R}_i - \bar{R} + 1 \quad \text{for} \quad x \in L(y_0; K(y_0)),
\]

(28)

where \( \bar{R} \) is a sufficiently large number.

Proof

See [10].

□

Lemma 3.4

Let \( y_0 \in Y_{np} \) and \( w(z) \) has no poles on \( L(y_0; N) \) where \( N \) can be taken as an integer. There are numbers \( \tilde{K} = \tilde{K}(y_0) \) and \( \sigma = \sigma(y_0) > 0 \) such that

\[
w(z) \text{ is holomorphic for } z \in P_\sigma(y_0; \tilde{K}(y_0)).
\]

and

\[
\Re w(z) < \bar{R}_i, \quad \text{for } z \in P_\sigma(y_0; \tilde{K}(y_0)).
\]

Proof

See [10].

□

Lemma 3.5.

Suppose \( w(z) \) satisfies the condition (18). Then, there is a sequence \( \{x_k\} \), \( x_k \to -\infty \) such that \( \Re w(x_k + iy_0) \to -\infty \).

Proof

See [10].

□
Lemma 3.6.

Suppose $w(z)$ satisfies the condition (18). Then there is a sequence
\[ \{x_k\}, \quad x_k \to -\infty, \]
such that $\Re w(x_k + z) \to -\infty$ uniformly on every compact subset of $P_\sigma(y_0; \overline{\mathbb{R}})$.

Proof

See [10].

□

Lemma 3.7.

Suppose that $w(z)$ satisfies the condition (18) for a $y_0 \in Y_{np}$. Then, we can take a number $\delta > 0$ such that there is a function $\tau_\delta(z)$ which is holomorphic in $S_\delta(y_0)$ with the property
\[ \tau_\delta(z + 1) = \tau_\delta(z) \tag{29} \]
and $w(z)$ is represented as
\[ w(z) = \phi(z + \tau_\delta(z)) \tag{30} \]
for $z \in S_\delta(y_0)$.

Proof

See [10].

□

Lemma 3.8.

Suppose for $\delta_1$ and $\delta_2$, $0 < \delta_1 < \delta_2$, there are functions $\tau_{\delta_j}(z)$, holomorphic and satisfying
\[ \tau_{\delta_j}(z + 1) = \tau_{\delta_j}(z) \quad \text{for} \quad z \in S_{\delta_j}(y_0), \]
such that
\[ w(z) = \phi(z + \tau_{\delta_j}(z)) \quad \text{for} \quad z \in S_{\delta_j}(y_0), \quad j = 1, 2, \]
then, we have
\[ \tau_{\delta_1}(z) = \tau_{\delta_2}(z) \quad \text{for} \quad z \in S_{\delta_1}(y_0). \tag{31} \]
4. Representation of the Solution

Theorem 4.1.

Suppose \( w(z) \) satisfies the condition (18). Then \( w(z) \) can be represented in the form (4).

Proof

Let \( y_0 \in Y_{np} \) such that (18) holds for \( y = y_0 \). Put

\[ \mathcal{D} = \{ \delta > 0 \mid \text{there is a function } \tau_\delta(z) \text{ which is holomorphic in } S_\delta(y_0), \]
\[ \tau_\delta(z + 1) = \tau_\delta(z) \text{ and } w(z) = \phi(z + \tau_\delta(z)) \text{ for } z \in S_\delta(y_0) \}. \]

\( \mathcal{D} \) is not empty, by Lemma 3.7. Let

\[ \delta^* = \sup \{ \delta \mid \delta \in \mathcal{D} \}. \]

Assume \( \delta^* < \infty \). Write \( y^* = y_0 + \delta^* \). Let \( z^*, \text{ Im} z^* = y^* \) be such a point that neither \( z^* \) nor \( z^* + 1 \) is a pole of \( w(z) \). Write \( z^* = x_0 + iy^* \) and \( z_0 = x_0 + iy_0 \). Let \( \Omega \) be the open rectangle with vertices \( z_0, z_0 + 1, z^* + 1, z^* \), and

\[ L^* = \{ z = x + iy^* \mid x_0 \leq x \leq x_0 + 1 \} \]

be the side of \( \Omega \). We write \( \tau_{\delta^*}(z) \) simply as \( \tau^*(z) \).

Take a point \( z' \in L^* \). Suppose there is a sequence \( \{ z_k \} \subset \Omega, z_k \to z' \), such that \( \{ \tau^*(z_k) \} \) is bounded. Let \( d \) be the number in Lemma 3.1 and \( N^* \) be a natural number so large that \( z_k - N + \tau^*(z_k) \in D(R, \beta; 2d), k = 1, 2, \ldots \). Then \( w(z_k - N^*) = \phi(z_k - N^* + \tau^*(z_k)) \) is bounded as \( k \to \infty \). Thus \( z' - N^* \) is not a pole of \( w(z) \). Since \( \phi(z) \) is univalent in \( D(R, \beta; d) \), we see that \( \tau^*(z) \) is holomorphically continuable to the point \( z' - N^* \), hence to the point \( z' \).
Therefore, if we put
\[ E = \{ z^* \mid z^* \in L^*, \tau^*(z) \text{ is not holomorphically continuable to } z^* \}, \]
then \( \tau^*(z) \to \infty \) as \( z \to z^* \) in \( \Omega \). Then \( \text{meas}(E) = 0 \), by the Theorem VIII of Lusin-Privalov [8].

Since \( E \) is closed, \( \tau^*(z) \) is holomorphically continued across each segment of \( L^* \setminus E \). Let \( \Gamma^* = \{ z = x + iy^* \mid x_1 < x < x_2 \} \) be one of such segments. There is a number \( \delta_1 > 0 \) such that \( \tau^*(z) \) is holomorphic in
\[ H = \{ z = x + iy \mid x_3 < x < x_4, | y - y^* | < \delta_1 \} \quad (x_1 < x_3 < x_4 < x_2). \]
If \( N \) is sufficiently large integer, then \( \phi(z - N + \tau^*(z)) \) is holomorphic in \( H \), hence we have \( w(z - N) = \phi(z - N + \tau^*(z)) \) also for \( z \in H \).

Take \( z^* = x^* + iy^* \in H, y^* < y^* < y^* + \delta_1 \). We can suppose \( w(z) \) has no pole on the line \( L(y^*; K^*) \) for a \( K^* \). If \( \{ N_m \} \) is a sequence of integers, \( N_m \to \infty \), then
\[ w(z^* - N_m) = \phi(z^* - N_m + \tau^*(z^* - N_m)) = \phi(z^* - N_m + \tau^*(z^*)) \]
is not bounded as \( m \to \infty \).

Hence \( \limsup_{x \to \infty} |w(x + iy^*)| = \infty \) and, by Lemma 3.7, \( w(z) \) is represented as \( w(z) = \phi(z + \tau^*(z)) \) in \( S_{\delta} (y^*) \). And \( \tau^*(z) \) is easily seen to be an analytic continuation of \( \tau^*(z) \). Therefore we may consider that there is a neighbourhood \( \mathcal{N} \) of \( E \) such that \( \tau^*(z) \) is holomorphic and one-valued in \( \mathcal{N} \setminus E \).

If \( \tau^*(z) \) has essential singularities at some points of \( E \), then \( \tau^*(z) \) would take values arbitrarily near to every \( \omega, |\omega| \leq \infty, \) in any neighbourhood of \( E \), since \( E \) is an \( N_\omega \) set because of \( \text{meas}(E) = 0 \). See [2], [4]. This contradicts with the meromorphy of \( w(z) \).

Thus, points of \( E \) could be, at most, poles for \( \tau^*(z) \). But if \( \tau^*(z) \) has a pole at a point \( z^* \in E \), then \( w(z) = \phi(z + \tau^*(z)) \) would have an essential singularity at \( z^* \), which also contradicts the meromorphy of \( w(z) \).
Therefore, E is empty and $\tau^*(z)$ is continued holomorphically across the whole side $L'$. By the periodicity relation (29), $\tau'(z)$ is continued holomorphically across the whole line $\{z| \text{Im}z = y' = y_0 + \delta^*\}$. Analogously $\tau'(z)$ is continued across the line $\{z| \text{Im}z = y_0 - \delta^*\}.

So, w(z) is represented as $w(z) = \phi(z + \tau_j(z))$ in a larger strip $S^*_\delta(y_0), \delta > \delta^*$, which contradicts the least upper bound property of $\delta^*$. Thus we conclude that $\delta^* = \infty$, and w(z) is represented in the form (4) for $|z| < \infty$.

\[\Box\]

Acknowledgements

I wish to express my thanks to Professor Dr Khin Myint Myint Aung, Head of Department of Mathematics, University of Kalay and Dr Salai Riang Vel, Professor, Department of Mathematics, University of Kalay, for their kind permission to do this paper. I would like to mention special thanks to my respectable Sayagyi, Dr Saw Win Maung, part-time lecturer, Department of Mathematics, University of Mandalay, who has given me invaluable advice and patient guidance that helped my research paper to accomplish.

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[10] Yanagihara, N., “Meromorphic solutions of a difference equation \( w(z+1) = w(z) + 1 + \frac{\lambda}{w(z)} \)

A Study on *Metta Sutta*

Khin Lay Swe  
Nam Myint Moe

Abstract

*Metta Sutta* is the ninth *sutta* of the *khuddaka Patha*. And it is also found in *Suttanipata*. This *sutta* was delivered by the Buddha to the five hundred monks. In this paper, there are basic principle how to practice before we do loving kindness meditation (*Mettabhavana*) to whom the person for the well-being of others, loving kindness meditation principles, benefit of loving kindness how to wish each other, and so on are presented in accordance with the *Metta Sutta* of the *pali literatare*.

Introduction

*Metta* is loving or unbounded benevolence shown towards others for their well-being. It is entirely free from attachment with others or desire (*ta h*) to live always together with others. People may be living poles apart and yet one in happy to hear that those living for away are prosperous. Such separation does not prevent one form feeling satisfied with their well-being. Therefore *Metta* is pure and noble and has been called also *Brahmavih ra* (*Brahma* = divine, and *vih ra* = living) That is to say, developing such love is living in a sublime state of mind.

1. The History Background of the *Mettā Sutta*³

One year, just before the Retreat, five hundred monks receive the meditation sermon from Buddha. At the end of the sermon, all five hundred monks leave for the forest continuous with the *Himavant* range, north of *S vatthi*. The forest is extremely pleasant, congenial to meditations, with shade and water so that it is considered a

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³ Vicitta U, 34  
Buddharakkhita, 8

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fitting place for a monk's endeavor. The monks slept there for a night and in the morning went for merit food in a nearby village of a thousand homesteads.

Being a distant provincial district, such gathering of monks was rarely seen. The monks, cultivators of meditation, were of clam mien. When the people beheld those monks they were full of venerations. *Idheva bhante temasa vasatha.* "Reverends, reside for the three months of Retreat with us." They requested. The place was appropriate for food, appropriate by way of climate and appropriated for shelter. The people built five hundred shelters with leaf-roofs within a day.

In respect of shelters, it is sufficient for the yogi intent on Nibb na not to lie down but to fit cross-legged, if the knees do not yet wet with rain. The people from the thousand homesteads went to the forest and two by two built leaf-shelters of six feet square so the work was finished in a day.

The monks went to the shelters only when it was very cold. Otherwise they sat in meditation under the three. When the monks meditated things happened to the tree-gods in the forest. Because of the power of morality of the monks for removal, the tree-gods came down from the tree mansions and holding their children by the hand, they went hither and thither. Now too the three-gods cannot live in their tree mansions because of the power of mortality of the monks but to go hither and thither, holding their children by the hand. Day passed. *Kad nukho bhaddhanata gamissanti* "When will the reverends level?" they asked each other from afar. It is like the rural people peeping and asking each other afar. "When will royalty living in our houses leave?" They consulted among themselves to create forms and sounds to drive away the monks. As greed, they created frightful forms and sounds at night. The monks saw and heard those frightful and sounds and could not undertake their practice. Progressively, they not only failed to undertake the regimen of monks but became afraid and lost consciousness. The tree-gods them emitted terrible smells. The monks contracted severe headaches dashes and daily became thinner. However they did not tell each other this matter.

About ten days later the senior monk spoke at the monk's assembly. Reverend friends, for a few days after you entered this forest your complexion was clear without blemish and your organs were lucid. Now you have become lean and your complexion sallow. What is there in this forest which is not a gradable? The senior monk asked of the assembly in four paragraphs. For a few days after you entered this forest your complexion was clear and your organs lucid. Now they have wasted away.
What is disagreeable in this forest? A monk replied. Reverend Sir, when night falls we see, hears and smells such frightful phenomena. For that reason we are unable to develop concentration. Because we see frightful forms hear fearful sounds and smell hideous odors our minds are unsteady. Day by day we grow emaciated. Another monk also reported what he saw. The senior monk they said. Reverend friends, the Bhagav allow the first Retreat month and the second Retreat month. Our Bhagav allow not one only way of Retreat. The first Retreat can be adopted beginning after the full moon of Wazo. If that is not possible the second Retreat can be adopted beginning the day after the full moon of Wagaung. Bhagav allows two methods of Retreat.

If that is so, this forest is not an agreeable place for us. Let us go, reverend sirs, to the Bhagav and ask for a place which will be suitable to us. When the older put the matter to the assembled monks, one and all agreed with the elder. In Brief, they cleaned their resting-places and journeyed the far distance back to the Bhagav in S vatthi. Bhikkhus, the rule has been established that there should be no travel during the rainy months. Then why are you bhikkhus going about? "Haven't I not laid down the rule that you should not travel during the period of the Retreat? Why do you travel?" asked the Bhagav. The monks reported the dangers extend in their place of residence. The Bhagava considered where outside southern Jambudipa there would be a place appropriate for the monks but could find no spot even so large as the size of a bed. The Bhagav looked at the forest where they had stayed and found it to be a place to support the realization of the Fruition of Arahatta. Return now, if not in time for the first Retreat than for the second Retreat. That place will benefit you in the realization of the Fruition of Arahatta. If you wish to secure your selves from the dangers of the three gods learn this protective partita. Bhikkhus, this partita will be a safeguard for you and a means for the development of concentrative meditation.

After indicating the benefits Buddha preached the Metta

1. Vicitta U, 56-60
Sukhino va khemino hontu, sabba satt bhavantu sukhitatt

(4) Ye keci p nabh tatthi, tas v th var va nava ses
D gh v yeva mahant, majjhim rassak a ukath l

(5) Di h v yeva ad ih, yeva d re vasanti avid re
Bh t v sambhaves va, sabba satt bhavantu sukhitatt M

(6) Na paro param nikubetha, n ti ma etha katthaci naki ci
By rosan pai ghasa a, n ama assa dakkha miccheyya.

(7) M t yath niyam putta, m yua ekaputta manurakkhe
Evwmpi sabbab tesu, m nasam bh vaye aparim a M

(8) Metta ca sabbalokasmi, m nasam bh vaye aparim a
Udda adho ca tiriya ca, asamb dham avera masapattam.

(9) Ti ha cara nisinnova, say no y vatassa vitamiddho
Eta sati adhi heyya, brahma meta vih ramidham hu.

(10) Di hi ca anupaggamma, s lva dassanena sampanno^1

K mesu vinayya gedham, nahi j tuggabbha seyya puna ret 'ti^1.

2. Basic Principle How to Practice Before We Do Loving-kindness Meditation^2

Mett^3 should be practiced direct towards oneself. In doing so a person should change his mind and body with positive thoughts of peace and happiness. He should think how he could be peaceful, happy, and free from suffering, worry and anger. He becomes ever to learn and tries his best not to give occasion for anger to rise. By loving-kindness, he cuts of all hostile vibrations and negative thoughts.

He returns good for evil, love for anger. He becomes ever to learn and tries his best not to give occasion for anger to any. Himself becoming with happiness, he rejects happiness into others not only inwardly but also outwardly by putting his Matt into practice in the course of his daily life. When he is full of peace and is free from thoughts of hatred, it is easy for him to radiate loving-kindness toward others.

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1. Sn, 300
Khu,10
A.III, 1. A, A.III, 193
Chalmer, 36
2. Narada, 12
3. amity; benevolence. CPED, 211
What he does not pass, he cannot give to others. Before he tries to make others happy, he should first be happy himself. He should know the ways and means to make himself happy. The new radiates his loving-kindness towards all his near and dear ones individually and collectively, wishing them peace and happiness and freedom from suffering, disease, worry and anger.

Diffusing his thoughts of loving-kindness towards his relative and friends, he radiates them also towards neutrals. Just as he wished for the dear ones even so he sincerely wishes for the peace and happiness of those who are natural to him, wishing them freedom from suffering, disease, worry and anger, finally, though this is somewhat difficult, he should radiate his Matt in the same way towards those who are inimical to him. If by practicing Mett K n n inimical towards him; his achievement would be more heroic and commendable. As the Buddha advice Admits those, who hate him live free from hatred.

Staring from himself he should gradually extend his Matt to words all beings, is respective of creed, color, or sex including dumb animals, until he had identified himself with all making no distinction whatever. He merges himself in the whole universe and is one with all. He is no more dominated by egotistic feelings. He transcends all from of separatism. No longer confiding himself to water-tight compartments, no longer influenced by caste, class national, racial or religious prejudices, he can regard the whole world as his mother land and all as fellow-beings in the ocean of life.

2: 1- Loving Kindness Meditation

A meditating should be fully equipped with the fourteen qualities. They are:

\[
sakko uju ca suhuju ca, suvaco cassa mudu anatim n,\]

\[
Santussuko ca sabharo ca, Appakicco ca sallagukavtti,\]

\[
Santindriyo ca nipako ca. Appagabbho kulesva nanugiddho.\]

(1) sakko ca = Competent and energetic
(2) uju ca = Straight forward in behavior and speech

---

1. Vicitta U, 64
(3) suhuj cs = Upright. A virtuous person guards the physical, verbal and mental behavior.

(4) suvaco ca = Amenable to admonition by wise persons. Today, a person who wishes to practice to attain the Way, Fruition and jh na should be amenable to guidance by wise, virtuous persons. A person not amenable retaliates with vituperation.

(5) Mudu = Gentle in physical and verbal expression.

(6) Anati m n ca = Humble. All varieties must be removed in meditation.

(7) Santussuko ca = Contented with whatever one has.
   The mediator should not be fastidious, should be content with whatever food, clothing or shelter is available, be it sweet or sour.

(8) subharo ca = Easily supported.
   Does not ask for sour or salt when sweet is available. East whatever is offered.

(9) appakicco ca = Have few concerns
   The meditation should not have other concerns.

(10) sallahukavutti = Frugal
   Like the bird which carries only wings wherever it goes the mediator should carry only the eight requisites, should travel light.

(11) santindriyo ca = Serene in the faculties
   The eye, ear, nose, tongue, body and mind should serene and not fidgety.

(12) nipako ca = Prudent
   The mediator should be skilled and wise. In meditating on loving-kindness, one should be practiced. In meditating on the five aggregates one should be skilled with respect to them.
(13) Appagabbho ca = Not impudent in physical, verbal or mental behavior. To be impudent physically is to assume an inappropriate seat in the Saṅgha assembly. To be impudent is to be vociferous in the Saṅgha assembly. To be mentally impudent is to thinking thoughts of sensuality, malevolence and cruelty.

(14) Kusles = Be unattached to lay devotees.

There should be no attachment though greed to buy devotee. Thinking;" my supporter; food donor", is permissible but not is greed. One should bestow loving-kindness as donor of the four, requisites.

2: 2 How to Wish Each Other¹

Metta ca Sabbalokasmi, m nass bh vaye aparim sa a ,

udha adho ca tiritya ca, asamb dha averamasapta M

A person should ceaselessly develop a loving mind without location restriction, enmity or malice to all beings is the formless sphere above, the sensual below and the corporeal Brahmās sphere in the middle.

A mediator in the sensual sphere should not restrict loving-kindness only to residents of the sensual sphere but should expand it to cover all beings in all their spheres. This is loving-kindness not restricted to one location.

"I'd like to send my love but since it will not be accept it will have to return even while it on its way". Loving-kindness should not be live that, loving-kindness should not be restricted in terms of location, should be wholly free from enmity and from malice.

Adapting any posture: tittha cara nisinnova, Say no y vatassa vitamiddho,

eta sati adhi heyya, brahma meta vih ramidha m hu.

¹ Vicitta U, 88
Dwelling in loving-kindness is noble. It is a pure abiding, as stated by Buddha and all virtuous persons. Before one sleeps, while lying, standing, sitting or walking, diffuse loving-kindness while in these four postures. If you wish to practice inbreathing meditation you cannot do it while walking, standing or lying down. You have to do it in the sitting posture. Loving-kindness can be diffused while adapting any posture. It is easy mode of meditation.

From *Mett* to Insight Meditation:

\[
\text{Di hi ca anupaggamma, slav dassanena sampanno.}
\]

\[
K mesu vineyya gedha , na hi j tuggabhaseyy puna reti.
\]

This last verse shows the transit of loving-kindness meditation to insight meditation (*vipassan*). A person should not enter upon wrong view with respect to soul and individually.

Buddha has declared. The mediator on loving-kindness, whether meditating on comprehensive love, love to groups of three, love to groups of two or love to ameliorate suffering due to lack of prosperity will be developing concentration on "being", and could there by slip into false view with respect to soul. The mediator on loving-kindness who transits to *vipassan* should practice mindfulness of *Anatta* (no-soul) so as not to enter upon false view with respect to soul or individually.

### 2.3 The Eleven Benefits of Loving-kindness

The *Mett Sutta* has laudatory verse.

\[
Yass nubh vato yakkh , Neva dassenti bh sana .
\]

\[
Ya hi cevanuyonjato, ratti diva matandito,
\]

\[
sukha supati sutto ca, p pa ki ci na passati,
\]

\[
evam di gun petam, parittam ta bha ma he.
\]

---

1. Vicitta U, 62
Those are the laudatory verses. The laudation verse states that eleven benefits accrue, including sleeping pleasantly and having no bad dreams. Eleven benefits are acquired when loving-kindness meditation is practiced. Those Eleven benefits are-

(1) sucha supati = sleep pleasantly
(2) such bujjhati = wake pleasantly
(3) na p paka supina passati = dream no frightful or obscene dreams
(4) manuss na piyo hoti = receives the love of all persons in sight
(5) amanuss na piyo hoti = receives the love of all Deva in sight
(6) devat rakkhanti = Devas safeguard continuously
(7) n ssa aggi v disa v sattha v kati = five will not consume, poison harm nor swords, operas, weapons, penetrate to body of the person who practice loving-kindness.
(8) tuva a citta sam yati = concentration is developed rapidly
(9) mukhava o vip pas dati = the complexion and feature are clear and fair.
(10)asamm ho k am karoti = dies lucidly
(11)uttariapp aivijhanto brahm lok pago hoti = even if the higher supramundane way and fruition are not achieved, existence in Brahman realm is assured.

The eleven benefits of loving-kindness meditation is preached by Buddha the Book of eleven of the A guttara Nik ya. These benefits are indicated by "eva m digu" in the laudatory verse.

3. To Whom the Person for the Will-Being of Other1

D gh v yeva mahant , majjhima rassak anukath 1.

Whatever being three be long or big, middling, short or small or fat. The

PM

PM d gh = Being possessed of a long body.

M

M mahant = Being possessed of a big body.

RM

RM majjhim = A middling being.

1. Vicitta U, 76
These six categories of being can be grouped into three classes of three.

A being possessed of a long body can be classed with one possessed of a short body and one of middling length. This is meditating on loving-kindness of three.

A being possessed of a big body such as the god Rahu Asurinda, an elephant on land or whale in the sea can be classed with one possessed of a small body and one of middling size. This is also meditating on loving-kindness. A being possessed of a fat body can be classed with one possessed of a thin body and one of middling size. May all such beings be endowed with physically well-being and happiness? This is meditation on loving-kindness of the third group of three.

\[ Di \ h \ v \ yeva \ adi \ h , \ yeva \ d \ re \ vasanti \ avid \ re. \]

\[ bh \ t \ va \ sambhaves \ va, \ sabbasatt \ bhavantu \ sukhitatt \ M \]

The noble Aararat who has completed the journey of sas ra and will not happen again, and worldly being, sot panna or sakad g mi who have not completed the journey of sa s ra and are still searching.

Alternatively, beings that have been born into the present and beings that are still in conception may all such being without exception is endowed with physical well-being and happiness.
This is grouping beings into two and meditating on loving-kindness of the two. There are four groups of two.

The ways of Ahitadukkhanagamapath na Mett

\[
\begin{array}{cccc}
  m & \tilde{n} & K & M \\
  a & K & \tilde{n} & M \\
\end{array}
\]

(1) Let not a person deceive another. This is to develop one kind of loving-kindness. Why do people have unfriendly feelings for each other? It is because they are deceiving each other. So let not a person deceive another. Deception is the cause of suffering due to lack of prosperity.

(2) Let not a person hold another in contempt in any matter who so ever.

People suffer because they hold each other in contempt. When there is contempt quarrels happen. This leads to lack of prosperity, which is the cause of suffering.

Not holding anyone is contempt in any matter anywhere what so ever is another loving-kindness.

\[ vy \text{ rasan pa ighasa a, n ama assa dukkha miccheyya. }\]

(3) Let not a person cause suffering to another through desire to impose physical or verbal restraint to cause mental distress.

a. Three ways of loving-kindness to remove lack of prosperity, 
b. Three sets of two ways of loving-kindness, 
c. Four sets of two ways of loving-kindness, and 
d. One way of loving-kindness encompassing all beings.

Altogether eleven ways of meditating in loving-kindness. A spread of eleven ways is offered for a person to choose.

Buddha offered eleven ways of loving-kindness for sons and daughters to select whichever is most appropriate to them.

Maternal kind of love: M t yath niyamputta,m yuss ekaputtamanurakkhe.

\[ Evampi sabbaabh tesu,m nas bh vaye aparim a . \]
Just as a mother would protect the only child of her womb with her life, even so let one cultivate boundless love toward all beings.

When practicing the meditation on loving kindness considers yourself as the mother of the universe and all human beings, Deva and Brahma as your only child to suffuse with undifferentiated love. Do not say I will love this person but not that love should be boundless. All must be conveyed into one’s loving sphere. The principle is that the mediator on loving-kindness develops a maternal kind of love.

**Conclusion**

*Mett cetovimutti-* universal loving leading to liberation of mind, signifies the attainment of *sam dhi*, absorption based upon meditation as *mett*. Since *mett* liberates the mind from the bondage of hatred and anger, selfishness, greed and delusion, it constitutes a state of libration. Every time one practices *mett*, for however short a period; one enjoys a measure of freedom of mind. Measureless freedom of mind, however, is to be accepted only when *mett* is fully developed into *sam dhi*.

The various applications of *mett*, as indicated by the terms "practice, developed", etc, signify a well-structured force brought about not only by specific hours of meditation, but also by converting all one's deeds, words and thoughts into acts of *mett*.

By "practices" is meant the ardent practice of *mett*, not as a mere intellectual exercise, but by committing oneself whole-heartedly to it and making it life's guiding philosophy, something which conditions one's attitudes, outlook and conduct.

The benefits of *mett* are indeed great comprehensive. For a follower of the Buddha, this is on supreme instrument that can be wielded with advantage everywhere.
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SOCIAL TEACHINGS IN SOME SUTTA OF BUDDHIST LITERATURES

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Abstract

Buddhist thought based on psycho-ethical aspect intends to uplift morality spiritual life, social relation, prosperity and finally to attain supreme happiness. Therefore it can support human beings to improve well-being in the present existence and also in the next existences. Although they existed from the longtime, they are still applicable in human affairs. The aim and objective of this paper is to focus Buddhist social teachings from the Myanmar Buddhist literatures. It can hope that this paper provides to develop personal and proper social life.

Key words: Social Teachings, Personal, Social Life

Introduction

Buddhist teachings are very different from that of other non-Buddhist teachings. The other teachings in the respective religions emphasized the importance of supernatural being as a creator or substantial being. In Buddhism, however, there is no room for such things. Buddhist teachings stressed the creativity and strengths of human being. Man is a master of his life and the rise and down of human life are in the hand of him according to Buddhist thought. It indicated directly the advantages of man and his community. Therefore Buddhist teachings are humanistic in character.

In this paper, social and teachings expounded in the Nikāya Sutta, commentaries and Myanmar Buddhist literature will be presented by the use of descriptive method and evaluative method. In reality, they are still living in the lives of many people.

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Social Teachings in Some Sutta of Buddhist Culture

A psycho-ethico doctrine, disciplines for monks and Buddhist's past stories Buddhist social teachings can study especially in Sutta. The teachings or Dhamma are very useful for those who have willing to improve their ethical and social lives. Here Buddhist social teachings will be presented from some Suttas and commentaries in Myanmar Buddhist literature.

Social Teachings in Sigālovāda Sutta

Sigālovāda-Sutta is well known teaching taught by Buddha Himself for social and ethical obligations. Buddha preached this Sutta due to the request of young Brahmin Singala. In it, the meaning of six quarters in Buddhist culture, the duties of the parents and children, the duties of the husband and wife, the duties of employer and employee, the duty of the good friend the characters of good and bad friends are mentimed for the benefits of social relations in a society.

The Meaning of Six Quarters and Duties of the Different Kinds of Persons

In Buddhist Sociology, according to Sigālovāda- Sutta, there are six quarters and their meanings to know properly. The parents as the east quarter; wife and children as the west quarter, the teacher as the south quarter, friends and companions as the north quarter, the employer as the Zenith quarter and the employee as the nadir quarter. In Sigālovāda Sutta, duties of the different kinds of person are mentioned in detail.

The Duties of the Parents and Children

The duties of the parents to his childrens are mentioned as follows.

1. Restrain in from evil
2. Guidance to the good
3. Training
4. Arrangement of suitable marriges in due time.
5. Handing over the inheritance

The obligations of the children to their parents are expressed as follows,

1. Support
2. Performance
3. Maintenance the lineage and tradition
4. Giving alms and performance of religious rites
5. Preservation of inheritance.

By doing the above five duty, the eastern quarter is protected and made safe and secure according to Buddha.

The Duties of the Teachers and pupils

Like the obligations of parents and children, the duties of teacher and student are also prescribed in Sigālovīda- Sutta as follows,

1. Training well
2. Instruction
3. Making grasp what the pupils has learnt.
4. Introduce friends and companions.
5. Providing for security

Teachers, thus ministered to as the southern quarter by their pupil, show their love for their pupils in above five ways

The Duties of the Pupils

1. Rising from his seat to slute
2. Waiting
3. Eagerness in learning
4. Personal service
5. Accepting respectfully
A pupil should care to his teacher as the southern quarter in above five duties. In this way, the southern quarter is protected and made safe and secure for the pupil.

In order to create a happy family, Buddha instructed the duties of husband and wife in Sigālovāda-Sutta as follows;

**The Duties of Husband and Wife**

A husband ministers her wife in the following five ways.

1. Respect
2. Courtesy
3. Faithful to her
4. By handing over authority to her
5. By providing adornment to her

The wife also takes care and loves in the following five ways:

1. By doing her duty well
2. By hospitality
3. By her fidelity
4. By looking after his earnings
5. By skill and industry in all her business dealings

Thus the western quarter is protected and made safe and secure for him.

**The Duties of the Friends and Companions**

In Sigālovāda-sutta the duty of the friends and companions is established in order to make sound social relations among people. The friends and companions indicate the north quarter.

1. Generosity
2. Courtesy
3. Benevolence
4. Equality (treating them as he treats himself)
5. Being true to his word.

Vice versa the friends and companions in turn also minister and love a person in the five ways; A man was protected when he need in protection; he gets care of wealth when he is unable to; he gets refuge in danger; he is not given up in his troubles; and he and his relatives get respect.

In this way the northern quarter is protected and made safe and secure.

The Duties of Employers and Employees

The duties of employer (master and) employee (servant) are prescribed in *Sigālovāda sutta*. An employer takes care to his servants and employees as the nadir in the following five ways;

1. By assigning they work
2. By supplying them with foods and moneys
3. By tending them in sickness
4. By sharing them with unusual delicacies, and
5. By giving them leave and gifts at suitable times.

In this way, servants and employees love their employer in the following five benefits.

1. The servants wake up before their employer
2. The servants go to bed after their employer.
3. The servants take what is given to him
4. The servants do their work well and
5. The servants speak well and give their employer a good reputation

In this way love, peace, harmony, loyalty, sympathy unity and faithfulness between the importance of reciprocity and loving-kindness among the human beings. Thus the nadir is protected and made safe and secure.
The Duties of Laymen and Brahmin

A lay man should minister to Brahmin well in the following ways. It is also prescribed in *Sigalovāda sutta*.

1. Give affectionate acts
2. Give affectionate words
3. Give affectionate thoughts
4. Open house for them and
5. Supply them with their needs

Thus the Brahmin also shows his love for the lay men in the following six ways.

1. The Brahmin keeps them from evil
2. The Brahmin exhort them to do good
3. The Brahmin loves them with kindly thoughts.
4. The Brahmin instructs them what they have not study.
5. The Brahmin instructs them what they have learnt.
6. The Brahmin shows to them the way to heaven.

In this way the zenith protected and made safe and secure.

Six Ways of Dissipation Wealth

The six ways of dissipating wealth are mentioned in *Sigalovāda sutta*.

It is very important for a man in the process of development in human life. They are as follows;

1. Drink
2. Going the streets at not suitable times.
3. Haunting fairs
4. Gambling and
5. Associating with bad friends and
6. Laziness

A person who wants to be a rich man should avoid the above six ways in his life.

Four Kinds of the Good Hearted Friends and their Characters

In Sigalovāda sutta the four kinds of the good-hearted friends are showing; (1) the helper, (2) the friend who is constant in happiness and adversity, (3) the friend of good counsel and (4) the sympathetic friend.

The Four Qualities of the Friend who is helper

- He protects one when he is taken unawares.
- He protects one's richness when he is unable to protect it.
- He is a refuge for one when he is afraid.
- When one has tasks to do, he provides twice as much help as one may need.

The Four Qualities of the Friend who is Constant in Happiness and Adversity

- He tells his secrets.
- He does not break one's secret.
- He does not forsake one in one's troubles
- He will even lay down his life for one's sake.

The Four Qualities of the Friend of Good Counsel

- He restrains one from doing wrong deed.
- He enjoys one to do what is right.
- One learns what one had not learnt before from him.
- He indicates one the way to Heaven.

The Four Qualities of the Friends who is sympathetic

- He does not rejoice over one's misfortunes.
- He rejoices with one in his wealth.
- He restrains those who speak ill of one.
He commends those who speak well of one.

Thus, the four kinds of good-hearted friends and their natures are explained in detail *Sigalovāda Sutta*. In fact such kinds of friend are very rare. We can encounter with those who are not real friend near us. We, ourselves should tried to be a good-hearted friend for the others. In *Sigalovāda - Sutta* the kinds of pseudo friends and their traits are also explained to be known noted in our lives. The following are the four Kinds of pseudo- friends and their natures.

The Four Persons who the Not Real Friends

1. The Rapacious Person.
2. The Person who Pays lip-service
3. The Person with Flattery and
4. The Wastrel.

The characters of the first kind of person are shown as follows;

He is rapacious

He gives little and wants much.

He does what he has to do out of fear and

He tried to seize his own interests

The characters of the second person are as follows

He makes friendly professions as regards the past makes friendly profession as regards the future; the only service he renders is by his empty sayings; when the opportunity for service arises he shows his unreliability.

The characters of the third person are; he approves your bad deeds, as well as your good deeds, he praises you to your face and in your absence, he speaks ill of you.

The characters of the fourth person are he is your companion when you go drinking when you frequent the street at untimely hours; when you haunt shows and fairs; when you gamble.

The wise and virtuous persons should try to avoid absolutely just as a person who travelling in dangerous journey.
Social Teachings in *Mangalā Sutta*

*Mangalā sutta* one of the social teachings taught by Buddha Himself, guided men to practice and follow for their benefits in social, moral economical and religious affairs. At the time of Buddha, most men and devas had tried in vain to discover the fundamentals of peace, happiness and prosperity. Buddha had expounded such fundamentals involved in the *Mangalā Sutta* or Thirty Eight Blessings. These blessings can remove and suppress all evils and bring about happiness, prosperity and wealth.

Thirty-eight Blessings can be classified into two types generally, Blessing for the secular life and Blessings for the supramundane. The Blessing for the supramundane comprised the right or middle ways to Ultimate Liberation of Buddhism. The Blessings for the secular life imply obligations, moral duties, social relation, admonition economical or business rules etc. In fact most of the verses in *Mangalā Sutta* are indicating for the benefits of present lives rather supramundane. Since this paper is dealt with social teachings, some verse which is directly concerned with such social teachings will be presented.

**Not to Associate with Fools, to Associate with the Wise, and to Honor for those who are Worthy of Honor**

Not to associate with the fool is the supreme auspiciousness. Live away from the fool is one of the supreme auspiciousness. If a person associates with fool, he will lose benefits both at the present and the lives after death. A person done in the wrong way in physical, verbal and mental deeds is a fool. In other words, doing ten evil moral conducts is regarded as a fool, doing unfruitful things for self and others is certainly a fool.

On the contrary, to associate with the wise is the highest auspiciousness. Staying together with the wise is one of the highest auspiciousness. If a person who associate with a wise, he will gain advantages at the present and rebirth. The opposite characters of the fool are called the attributes of the wise. He avoids the ten evil deeds and preserves the ten good conducts. He is also doing fruitful things for self and the others.
According to Buddha, honoring those worthy of honour is the highest auspiciousness. Honoring (respecting) is beneficial for both and is the highest auspiciousness. The Buddha, Semi-Buddha (Pacceka) and Arahat are worthy of honour. In human realm, parents, teachers, and other respected persons are worthy honour.

There are two kinds of honouring, Dhamma and Alms giving (generosity). Doing honour by generosity is called honouring in generosity and doing honour by practicing is called Dhamma Honouring. We should be done in these two honouring regularly in daily life. For Buddha, Dhamma honouring is properly beneficial for self and the future existences. Honouring in generosity is truly beneficial for both self and rebirth (Sāsana). According to Buddha, Dhamma honouring is the best. One of the Dhamma honouring is the practicing in Fourth Noble Truth which consists of morality, concentration and wisdom, these paths are called the Middle Way in Buddhist ethics and they three lead to attain ultimate release in Buddhist philosophy. The Buddha the Exalted One prefers much to Dhamma honouring.

The above three Blessings are concerned with social dealing and therefore we should practice these Blessing.

Supporting One's Father and Mother, Cherishing Wife and Children

These Blessings are called Blessings of Obligation and Responsibility. In a society man is a member of society and who has obligation and responsibility, to make a peaceful and happy family, all individuals should follow and preserve social duties and moral codes prescribed by the respective communities. In Mangalā Sutta these obligations reveal to practice for everyone.

According to Buddha, Parents are like brahma, and they are first teachers. So they are worthy of honour. They are also everlasting benefactors. That great gratitude never can be fully repaid. We should therefore know the gratitude of parents and if we repaid, it is the highest blessing.

In Chinese thought, Confucians also indicate the value and importance of the role of parents and the duties of the children. The word Filial Piety shows the responsibility of the children towards their parents. In showing honoring the parents, the children should try to protect their bodies from harm and danger, because it is the
result of the parents. By doing well and making the parents name honoured. The children must understand the gratitude of the parents. They must do for physical care of the parents. They also fulfill the spiritual and emotional needs. They continually must fulfill the aims and purpose of the departed spirits or deceased parents. In this way the duties of the children are mentioned in ancient Chinese philosophy.

In Sigālovāda Sutta Buddha had been taught the duties of the children in five ways. It was expressed in the duties under the social teachings is Sigālovāda Sutta.

Parents must support their childrens before they grow. It is also expounded in the duty of children in Sigālovāda Sutta. They are; to forbid them from misconduct and to show the way to good-conduct, to make them learn the skills, to marry them with suitable persons; to give helps for investments. These are the five duties of parents. These five duties of parents are mentioned in Sigālovāda Sutta. In some situations some parents are unable to support their children due to economical and social conditions. They are not dutiful for the cultivation, nurture, training to improve their children lives. They lack in duty for caring their children. As a result, the children can weak and poor in good mental and physical tendencies in the future. Even some parents sell them to other in order to solve the family problems. Their activities do not agree with the duties of parents in Buddha's Blessing.

A wife is a responsible in health, nurture and feed of her husband and children. Sometimes he suggested her husband's business in order to improve properly. She is a maker of happy family. She should have a good temper to support the relatives in both sides. If she has a good ability to control and rule her family, the family will develop in economics, social relation. If she has no ability to control her family, her family will decrease in social, economical and religious affairs. So she is a very important parson in a family.

“Be kind and adore, not treating in insolent manner. Not engaging in sexual misconduct, giving authorities over domestic matters, and providing with garments and or aments are the five duties of a husband.” (Walpola Rahula, “What the Buddha Taught”, p.98).

Buddha, therefore, teaches that supporting wife is the highest blessing.
A Highly Trained Discipline, the Pleasant Speech

Buddha teaches to be well-trained and the beneficial speech in His Blessings of Learning.

For the laymen, avoiding ten evil conducts is certainly the highest blessing. Ten kinds of evil conduct are as follows,

1. Killing, stealing and committing sexual misconduct are three bodily evil conducts.
2. Lying, slandering, harsh speech and vain talk are four verbal evil conducts.
3. Covetousness, ill-will and wrong view are four mental evil conducts.


To be beneficial for this present life and circle of birth (Samsarā) avoiding ten evil conducts is highest auspiciousness. It is also basic morality of Buddhist ethics.

The beneficial speech means Right Speech in Buddhist culture. If a man avoid speaking the four evil speech, his speech is beneficial speech and it is highest auspiciousness.

Liberality, Righteous Conduct, the Helping of Relatives

The above four blessings are under the blessings concerning social obligation, Obligation is one of the kinds of duty, but it is not the same meaning with duty. Every religion in the world teaches to do such kinds of obligation.

Donating all kinds of things is known as Dana in Pali. It is one of the ten meritorious deeds in Buddhist culture. It is also called Almgiving, offering or charity. Giving away as a gift or donation is Dana. If one gives with a firm belief in Kamma and its results and if one does so with keenness and a feeling of joy at the time of giving and also before and after the dāna is indeed a great gift-Liberality, especially the offering of robes, food, etc. to the monks, is highly praised in all Buddhist countries,
as a fundamental virtue and as a means to suppress man's inborn greed and egoism. Liberality based on the belief in Kamma and its results is the best kind of Dana. Hence one should make Dana as much as he can in daily life. It is one of the obligations and highest Blessing in Buddhist culture.

Righteous conduct means practicing ten good deeds and developing four Foundation of Mindfulness or Awarenesses of Mindfulness. If one practices them, it is high blessing. The ten good deeds (Sucarita) are opposite of ten bad deeds. "Refraining from killing, stealing, sexual misconduct, lying, slandering, harsh talk, frivolous speech absence of covetousness, ill will and false view are called ten meritorious deeds. It can be regarded as the foundation of morality. The four foundation Mindfulness (Satipatthāna) are ;"contemplation of body, feeling, Mind and Mind object.

After each the contemplation it is shown how it finally leads to Insight. So such practicing is one of the kinds of righteous conduct. Therefore right conduct is the highest blessing in Buddhist life.

Man can not live without help and support of physical environment social environment and relatives. In order to improve one's life the help of relatives are actually required. In Myanmar society, seven generations of father and mother are the relatives. So if one has good conditions in economics he should not neglect and ignore them. One should aid them with money, cloth and other necessary things that they need and weak. So Buddha teaches that helping relatives is one of the obligations and it is Blessing one.

Reverence, Humility and Contentment

These three blessings are under Blessing of training the Blessing of mind. In Buddhist culture, reverence or respect to the elders is very humane and desirable action. It distinguishes man from brutal animals. In animal world, such noble behavior is not found. Especially in Buddhist culture reverence is more emphasized in human relation. One should pay respect elders at home, at work, at place that he lives. One respects elders such benefits will be gained as longevity, good looking happiness, wealth and strength.
Like reverence, humility is a cultured behavior in Buddhist society. It is practicing like foot-rug, an ox with broken horns; a snake without fangs is called humility. It is called as Nivata in Pali. One should have humble behavior when he relates to other persons at street, at wards that he stays, at business and every where he goes. it is also a honorable action in Myanmar Culture. As a result, he will be loved by the different kinds of man in our community and this action can provide to gain his personal interests. There is a saying in Myanmar society. It is that one does not die due to humble action. This action can also provide for the purification of mind.

If one is discontented, he is unable to deduce the appetite. Due to having appetite and discontentment, excesses occur. There are four kinds of excesses causing appearance of degeneracy: (i) eating excessively; (ii) sleeping excessively; (iii) gambling excessively; (iv) enjoying five objects of sensual desire excessively. These are the discontentment deed.

One should have contentment in his mind. If he lives in or earn his live by suppressing over greed, he can live in contentment. So it is necessary in our life. If men do under the guidance or influence of greed, without having contentment, he will meet miseries or troubles less or more. The opposite of contentment is known as greed. Buddha gives an example of contentment with the bird hood. A bird has only wings. So bird can fly in the air freely for lasting. The result of Contentment is that one's mind is peace and calm which lead to a happy life.

The above three are Blessings of training mind. They can support man to create good relations in his life.

Besides the above Blessings and Suttas, there are many social teachings in Myanmar Buddhist literature. For example, Dhammapada, Lokaniti, Dhammaniti, Proverbs, Sayings, Maxims and Admonition etc; they are proper guides to improve moral and social lives in the different kinds of men. They are exhaustless gems for human beings. They can make fruitfulness for those who applied them. Everyone, therefore, should follow practically in accordance with the valuable teachings.
Conclusion

Most Myanmar Buddhists believe and preserve in above mentioned of the Buddhist teachings. Under the teaching of Buddhist’s Dhamma, they should perform or their social relation in accordance with Buddha’s teachings. Social teachings for Loki are said to be good basis for the attainment of Lokuttarā fruitfulness. They are based on the belief in Kamma, morality and benefits of individuals and community. They are based on the power of man. They are therefore realistic humanism. It we practice and observe in accordance with the guidance of these teachings, though it cannot attain absolute happiness, we can gain happiness in celestial abode. The concepts of Kamma, impermanence, self-reliance, sympathy, contentment and loving-kindness etc; are essence of Buddhist thought which can lead to enhance for the peace and harmonious life and society. Buddha teachings, especially thirty-eight Blessings and Sigalovada -Sutta, lead to not only peace and happiness of family life in the present existence but also in pleasant state of next existence. However, if we break them we can reach evil realm. To be achieved in social activities, these noble attitudes and teachings as a guide should be held. Buddha’s Dhamma, therefore, is applicable in social life.

References

Construction of Temperature Monitoring System for Cold Chain

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Abstract

For the regions which have low electrical facilities and difficult transportation, to keep the effective vaccines by using the cold chain box for long period is needed. Thus, digital thermometer with long wire temperature sensor LM35DZ was constructed to determine the inner temperature of the cold chain box. Paddy-husk, cork-box, icebox (Sofrigam) were used to improve the time of temperature maintenance in cold-chain. Then, the thickness of thermal insulation material to maintain the temperature (+2°C to +8°C) was determined in the cold chain box. We found that, the time duration of temperature maintenance (+2°C to +8°C) was determined in the cold chain box. We also found that, the time duration of temperature maintenance in the cold chain box with thermal insulating material paddy-husk (30cm thickness and 70 kg mass) is 142.883hr. The resultant time duration of 143hr is enough for effective vaccine.

Introduction

A cold chain is a temperature-controlled supply chain, which maintains a given temperature range. It is used to help extend and ensure the shelf-life of products such as fresh agricultural produce, seafood, frozen food, photographic film, chemicals and pharmaceutical drugs. The uses of cold chains are common in the food and pharmaceutical industries and also some chemical shipments. One common temperature range for a cold chain in pharmaceutical industries is +2°C to +8°C. This is important in the supply of vaccines to distant clinics in hot climates served by poorly developed transport networks. Vaccines are delicate biological substances that can become less effective or destroyed if they are frozen, allowed to get too hot, exposed to direct sunlight or fluorescent light.

Kalay region and Chin State have low facilities in electricity and difficult transportation, thus they have no chance to use vaccine refrigerator and good cold chain. Therefore, we would like to construct the inexpensive temperature monitor for

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vaccine storage cold chain and how to maintain the required temperature in the cold
chain box.

Construction of Digital Thermometer

To measure the inner temperature of the cold chain system, first constructed the
digital thermometer which is based on microcontroller (PIC16F877A) and
temperature sensor (LM35DZ). The temperature in centigrade scale is displayed in
digital format on 16 x 2 character liquid crystal display (LMB162A). Temperature
monitor for cold chain system should be used temperature maintain monitoring for the
vaccine.

Figure (1) Block diagram of constructed digital thermometer

![Block diagram of constructed digital thermometer](image)

Constructed digital thermometer is composed of four main parts. They are regulated
power supply, temperature sensor unit, central processing unit and display unit. The
block diagram of the constructed circuit is shown in Fig (1).

5V regulated power supply was constructed by using LM7805 IC. LM35DZ
semiconductor was used as a temperature sensor unit. Central processing unit was
constructed by using Microcontroller (PIC16F877A). Finally, display unit for digital
thermometer was used Liquid Crystal Display (LMB162A).
The complete circuit diagram of the constructed system is shown in Fig (2). The photographs of constructed system in front view and rear view are shown in Fig (3) and Fig (4).

![Circuit Diagram](image)

**Figure (2) Circuit diagram of constructed digital thermometer.**

![Photograph](image)

**Figure (3) Photograph of constructed digital thermometer in front view**
Figure (4) Photograph of constructed digital thermometer in rear view

Figure (5) Temperature measurement of cold chain box by using the constructed digital thermometer
Development of Temperature Maintenance in Cold Chain System

The temperature maintenance in the cold chain system was investigated by using (i) the ice box with cork-box (ii) sofrigam ice box with cork box and then (iii) sofrigam ice box with cork-box and paddy-husk.

The sofribox refrigerated create makes it possible to store heat sensitive products in the required temperature range. The dimension of the cork-box (sofribox) is 26cm x 21cm x 22cm and thinness 2.2cm. The volume of outer cork-box is 0.012cm$^3$.

Icebox (sofrigam) offers thermal insulated and cooling packaging solutions that are efficacious and economical for air, sea and overland shipping and transport. Extreme precision measuring and cutting of the polyurethane allows us to optimize the weight, volume and overall cost of our cold-chain storage and transportation operation. The 0°C rigid snowgam guarantees perfect restitution for the cold storage environment and transport in +2°C to 8°C conditions.

![Figure (6) The application of sofrigam ice box with cork-box.](image)

In experiment, when the used of icebox is 2.49kg, the time taken maintained under 8°C is 51.3 hours or 2days. The time taken of temperature maintenance from 8°C to
2°C is measured in the cold chain box by using one sofrigam box, two sofrigam box and three sofrigam box. The variation of temperature range from 8°C to 2°C with time taken is shown by graphs. Then compare with outer temperature of cold chain box.

Figure (7) The temperature changes in the cold chain system by using the one sofrigam box. (16.083 hr).

Figure (8) The temperature changes in the cold chain system by using the two sofrigam boxes. (28.2hr).
Figure (9) The temperature changes in the cold chain system by using the three sofrigam boxes. (51.3 hr)

**Temperature Maintenance of Paddy-Husk**

For temperature maintenance in the range from 8°C to 2°C in the cold chain box, thickness of paddy-husk were investigated.

Figure (10) Improvement of temperature maintenance by using the Paddy-Husk
Fig (11) The time duration in the cold chain system by using paddy-husk (15 cm thickness and mass 18.337 kg) with the three sofrigam ice boxes is 126.283 hr.

Fig (12) The time duration in the cold chain system by using paddy-husk (30 cm thickness and mass 70 kg) with the three sofrigam ice boxes is 142.88 hr.

**Result and Discussion**

According to the figure (9), the time duration of temperature maintenance in the cold chain system by using the three sofrigam boxes is 51.3 hr. But the time duration of temperature maintenance in the cold chain system by using paddy-husk (30 cm thickness and mass 70 kg) and three sofrigam ice boxes is 142.883 hr. Since thermal conductivity of paddy-husk is low, the resultant time taken for maintenance in the range from +2°C to +8°C is about six days.
According to the above figure (13), for the regions which have low electrical facilities and difficult transportation, to keep the effective vaccines by using the cold chain box for long period is enough by using the three sofrigam boxes, 30cm thickness paddy-husk.

**Acknowledgements**

The authors would like to acknowledge the valuable comments, discussions and encouragement of Professor Dr. Kyaw Zaw, Head of Department of Physics, and University of Kalay. Then thanks all the Physics Association of Kalay University for their helpful discussions.

**References**


Preliminary Survey on Some Turtles and Tortoises in Kalay Environs

Myint Khaing¹

Abstract

Altogether 5 species of turtles and tortoises, distributed under 3 families and 5 genera were identified and described along photographic presentations. Out of the 5 species, 2 species are terrestrial, next 2 species are aquatic and 1 species is semi aquatic. Among the 3 turtle’s species, 2 are soft shell and 1 is hard shell species. The record species were tabulated and presented with colored photographs. Suggestions for future works were also outlined.

Introduction

Turtles are ancient animals that evolved into a shelled form over 200 million years ago. Together with lizards, amphibiaenids, snakes, crocodilians, and the tuatara, they constitute the vertebrate class Reptilia. Reptiles are ectotherms that, in part, have evolved walking limbs and a dry, scaly skin. They evolved from the amphibians during the Pennsylvanian Period, toward the close of the Peleozoic Era. During the following Mesozoic Era the reptiles underwent rapid adaptive radiation and became the dominant animals on earth. Reptiles, along with the amphibians, represent a transitional group in vertebrate evolution, occurring between the aquatic fishes and the terrestrial birds and mammals. Reptiles were the first vertebrates adapted to life in dry places. While it is true that many amphibians spend much time on land, their eggs must be laid in water or damp places. Reptiles were able to lay a specialized egg, which has a calcareous or parchmentlike shell that retards moisture loss. Hence, reptiles could take advantage of the great expanses of dry-land not previously available to their ancestors. Their eggs also have embryonic membranes (amnion, chorion and allantois ) that are not found in amphibian eggs, as well as a yolk sac that contains nutrients. The amnion forms a fluid-filled compartment surrounding the embryo, thus bringing the aquatic environment within the egg.

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Among the Myanmar chelonian species, five species are critically endangered, 10 are endangered, nine are vulnerable, three are near threatened and five remained as not evaluated.

Turtle populations have been declining at an alarming rate throughout the world in recent years. A number of factors have contributed to this decline. Over collecting is certainly a major problem. The volume of the pet trade has resulted in the removal of many adults from the populations, and the gathering of eggs and juveniles reduces the rate of replacement of those adults left to die of natural causes. Adults of many species are harvested for food. With their relatively slow rate of maturation turtles cannot withstands heavy cropping and still maintain their populations. Fortunately, recent salmonella scares and conservation legislation have reduced the pet trade in turtles. Insecticides and herbicides probably contribute to the decrease in the number of turtles. Large quantities of chlorinated hydrocarbons (ingredients in many pesticides) may be stored in the body fat and be released later to poison the turtle while it fasts. In urbanized countries the automobile has had a detrimental effect; thousands of turtles die on the highways each year; in all too many cases they are struck deliberately.

So, this research is undertaken with the following objectives. These are:

- to record the species of turtles and tortoises,
- to find out the distribution in Kalay environs and
- to promote a greater understanding chelonians and activity lead to their conservation for future generations.

**Material and Methods**

**Collection Site and Study Period**

The specimens were collected from Kalay environs. Kalaymyo is located between N between 22°36′ and 22°38′ and E between 93°58′ and 94°16′, a total land area of 238.44 km². The present research work was conducted from June 2010 to November 2011.
Data Collection

Freshwater turtles are collected from local people and hunters. They used fishing nets and hooks.

Many tortoises are collected by hand easily from Kyaungban Monastery in Kalaymyo.

Measurement of the Specimens

Measurements of different parameters such as carapace length (CL), carapace width (CW), plastron length (PL) and plastron width (PW) are measured by ruler. Body weights are measured by spring balances.

Identification of the Specimens


After identification the specimens were recorded with color photographs. Finally, the freshwater turtles and tortoises were set free away for conservation.

Observation and Results

*Indotestudo elongata* (Blyth, 1853)

**Scientific name** : *Indotestudo elongata* (Blyth, 1853)

*Testudo elongata* (Blyth, 1853)

*Testudo parallelus* Annandale, 1913

**Family** : Testudinidae

**Common name** : Yellow tortoise, Red-nosed Tortoise

**Vernacular name** : Leik war, See gyo Leik, Gin Leik, Leik na khaung ni, IngyinLeik, Taung Leik

**Type** : Tortoise
Carapace: The carapace is domed, but flattened dorsally with descending sides, has a shallow nuchal notch, a long narrow nuchal scute and the posterior marginals somewhat flared and serrated (more strongly serrated in juveniles). Vertebral 1 is about as broad as long, but 2-5 are broader than long; the 5th is expanded. Well-defined growth annuli surround the flat vertebran and costal areole. Usually 11 marginals lie on each side, and the undivided supracaudal scute is downturned between the somewhat expanded marginals. The carapace is yellowish brown or olive, with black blotches on the vertebrals and costal. Single large supracaudal scute over the tail.

Plastron: The well-developed plastron has a deep anal notch. Is forelobe tapers anteriorly and is shorter and narrower than the hind lobe. The gulars are somewhat thickened, and the bridge is wide with a small axillary and a larger inguinal scute. The plastron and bridge are yellow and usually unpatterned.

Plastron Formula: abd> fem> pect> hum> gul> an

Head: The head is moderate with a non-protruding snout and weakly hooked, tricuspid upper jaw. Its large prefrontal scale is longitudinally divided, and followed by a large frontal scale which is often subdivided; other head scales are small. The head is pale cream to yellowish green without dark spots or blotches. Pale head except during breeding season when area around nostril and eyes becomes bright pinkish red color.

Limbs: Limbs are brown to olive. The anterior surface of their limb is covered with moderate to small overlapping scales (the outermost largest).

Tail: Tail ends in claw-like spur. Males have longer, thicker tails, and deeper anal notch than do females.
Manouria emys (Schlegel and Muller, 1844)

Scientific name: Manouria emys (Schlegel and Muller, 1844)

Family: Testudinidae

Common name: Asian Brown Tortoise

Vernacular name: Leik balu, Peing Paung Leik, Leik maung (Rakhine), Chae Chauk Chaung Leik (Six footed turtle), Taung Leik gyi

Type: Tortoise

Carapace: Its oval carapace is domed with descending sides; however, it may be somewhat flattened across the 2d and 3d vertebrals. There is little indentation in the cervical region; instead both the anterior and posterior marginals are upturned and slightly serrated. A rather broad cervical saute is present. Vertebrals are wider than long; the 5th is expanded. Well-defined growth annuli surround the flat areolae of the vertebrals and pleurals. Eleven marginals lie on each side, and the supracaudals are divided both dorsally and ventrally. The carapace varies from olive or brown to black; vertebral and pleural areolae may be than in young individuals.

Plastron: The plastron is well-developed and has both an anterior and a posterior notch. Plastral lobes are almost equal in length and width. The pectoral scutes may or may not extend to the midseam. The gulars are thickened and extend beyond the carapacial rim. The bridge is wide; the two or more inguinal scales are larger than the single axillary. The plastron is yellow with black shading, usually around the periphery.

Plastron formula: abd>hum>gul><fem>an>pect

Head: The head is moderate to large with a non projecting snout and a slightly hooked upper jaw. Its prefrontal is divided longitudinally, and followed by a single large frontal scale; other head scales are small. The head is black with some pink, bronze, or brown pigment.
Limbs: Limbs are black. The anterior surface of each forelimb is covered with large, pointed, overlapping scales. Several very large pointed tubercles (spurs) occur on each thigh, giving rise to the colloquial name of “six-footed” tortoise.

Tail: Tails are black. The tail ends in a horny scale. Male have longer, thicker tails and more concave plastra than females.

**Amyda cartilaginea** (Boddaert, 1770)

**Scientific name**: *Amyda cartilaginea*

*Testudo cartilaginosa* Boddaert, 1770
*Testudo rostrata* Thunberg, 1787
*Trionyx stalatus* Geoffroy, 1809 Theobald, 1874 & 1875
*Trionyx javanicus* Geoffroy, 1809
*Trionyx cariniferus* Gray, 1855; Theobald, 1874
*Trionyx ornatus* Gray, 1861
*Aspilus punctulatus* Gray, 1864
*Trionyx phayrei* Theobald, 1868; Boulenger, 1889 & 1890; Annandale, 1912

**Common name**: Asiatic soft shell turtle

**Vernacular name**: Bee wun Leik, Kabar Leik, Byat Leik, Paung daung Leik, Za Wun Leik, Leik say way, Leik pati.

**Type**: Soft shell turtle

**Carapace**: The round to oval carapace is olive gray to greenish brown with numerous yellow bordered black spots and yellowish dots in younger individuals. In adults the yellow spotting tends to disappear and broad black radiating streaks develop. However many adult show no pattern and have uniformly olive carapaces. Several longitudinal rows of small tubercles are on the juvenile carapace, but these disappear in very large
adults, which have smooth carapace. A series of enlarged tubercles lies on the anterior carapacial rim above the neck.

**Plastron**: The white to grayish plastron has five callosities, which are coarsely pitted. Male have white plastra, female gray.

**Head**: The moderately sized skull has a bony snout which is much longer than the diameter of the orbit. A well-developed symphysial ridge occur on the mandible, which is equal in length to diameter of the orbit. No ridge occur on the maxillary triturating surface. Head, and neck are olive with numerous small yellow spots, and slightly larger orange to pinkish blotch may occur on the sides of the head behind the orbit. These light spots fade with age leaving a network of dark lines on the adult’s green head.

**Limbs**: Flattened and fully webbed. Outer three toes of each limb claw.

**Tail**: Males have long, thick tails width the vent near the tip: the tails of females are shot.

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**Lissemys scutata** (Peters, 1868)

**Scientific name**: *Lissemys scutata* (Peters, 1868)

*Emyda scutata* Peters, 1868; Anderson, 1879; Boulenger, 1889 & 1890; Siebenrock, 1909

*Emyda granosa scutata* Annandale, 1912

*Emyda fuscomaculata* Gray, 1973

**Common name**: Myanmar Flap Shell Turtle

**Vernacular name**: Zin Chaw Leik, Yay Leik, Leik Pyaung

**Type**: Soft Shell Turtle: Endemic species

**Carapace**: The oval, domed, unflared adult carapace is unique among trionychids in having a series of peripheral along the posterior
rim. A prenuchal is also present. Two neural bones separate the 1st pair of costals, and the seven or eight neurals lie in a continuous series. The 7th and 8th pair of costals touch medially. Rib ossification is extensive, and ribs protrude beyond the costals. All carapacial bones are finely granulated. Juveniles wrinkled carapaces with longitudinal rows of small tubercles, but the adult carapace is much smoother. The adult carapace varies from uniform brown to olive brown or dark green.

**Plastron**: The plastron is cream colored and has femoral flaps. There is a hinge on the plastral forelobe which allows it to partially close the anterior opening, thus protecting the head and forelimbs. This hinge lies at the point of attachment of the preplastral to the epiplastr. The hyo-and hypoplatra are fused, and posterior extensions are absent from the epiplastr. Seven plastral callosities occur in adult, but none in juveniles.

**Head**: The head is olive to brown with several elongated and wide yellow stripes: on the snout, one between the orbits, one passing backward on the side from the orbit to the tympanum, and sometimes one from the corner of the mouth backward along the throat. A series of yellow stripes also occurs on the neck.

**Limbs**: Flattened and fully webbed. Outer three toes of each limb clawed.

**Tail**: Males have long, thick tails; females have short tails. Females grow larger than males.

**Cyclemys dentata** (Gray, 1831)

**Scientific name**: *Cyclemys dentate* (Gray, 1831)

*Emys dhor* Gray, 1831 & 1834
Cyclemys dhor Gray, 1870; Morice, 1875; Boulenger, 1889 & 1890 Diebenrock, 1903; Smith, 1930

Cyclemys obiculata Bell, 1834 & 1842; Theobald, 1868; Sowerby & Lear, 1872

Cistudo dikardi Dum & Bib. 1835

Cyclemys oldhami Gray 1863; Guenther, 1864

Cyclemys ovata Gray idem

Cyclemys belli Gray, idem

Family : Bataguridae

Common name : Asian Leaf Turtle

Vernacular name : Leik pu, Phet Leik

Type : Hard shell Turtle

Carapace : The oval carapace is slightly arched and contains a single medial keel. Vertebrales are usually broader than long, but the 2nd to 4th may be as broad as long. The posterior border of the carapace is serrated, and all of the scutes have smooth surfaces. Carapacial color varies from light to dark brown, black, olive, or sometimes mahogany; narrow black radiations may be present.

Plastron : The adult plastron is narrower than the carapace, and notched posteriorly. The plastron varies from yellow or light brown, with dark radiations, to uniformly dark brown or black. Plastron with freely movable hinge between pectoral and abdominal scutes.

Plastron Formula : pect>abd>an>fem><gul>hum.

Head : The head skin is divided into large scales; dorsally, it is reddish brown while the sides and jaws are darker brown. The snout is slightly projected, and the upper jaw lacks tooth-like projections on each side.
**Limbs**

Legs are light brown with large transverse scales on the anterior surface. Digits half to fully webbed. Forelimbs are four claws and hindlimbs are five claws.

**Tail**

The male have longer, thicker tails.
Amyda cartilaginea
(Dorsal view)

Amyda cartilaginea
(Ventral view)

Lissemys scutata
(Dorsal view)

Lissemys scutata
(Ventral view)

Cyclemys dentata
(Dorsal view)

Cyclemys dentata
(Ventral view)
Table 1. Three families of recorded species, their mode of life and conservation status

<table>
<thead>
<tr>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
<th>Common name</th>
<th>Vernacular name</th>
<th>Mode of life</th>
<th>Conservation status</th>
<th>Location sites villages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testudinidae</td>
<td>Indotestudo</td>
<td>I- elongata</td>
<td>Yellow Tortoise</td>
<td>Leik war</td>
<td>Terrestrial</td>
<td>Endangered</td>
<td>Kalaymyo and Sakhangyi</td>
</tr>
<tr>
<td>Trionychidae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bataguridae</td>
<td>Cyclemys</td>
<td>C- dentata</td>
<td>Asian leaf Turtle</td>
<td>Leik Pu</td>
<td>Semi aquatic</td>
<td>Near Threatened</td>
<td>Htoma</td>
</tr>
</tbody>
</table>

Table 2. Carapace length, carapace width, plastron length, plastron width and weight of recorded species

<table>
<thead>
<tr>
<th>Serial No</th>
<th>Species name</th>
<th>No of Specimens</th>
<th>CL(cm) Mean</th>
<th>CW(cm) Mean</th>
<th>PL(cm) Mean</th>
<th>PW(cm) Mean</th>
<th>Weight (kg) Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Indotestudo elongata</td>
<td>16</td>
<td>15.78</td>
<td>11.09</td>
<td>13.53</td>
<td>9.56</td>
<td>22.32</td>
</tr>
<tr>
<td>2</td>
<td>Manouria emys</td>
<td>1</td>
<td>46 cm</td>
<td>35 cm</td>
<td>43 cm</td>
<td>34 cm</td>
<td>35 kg</td>
</tr>
<tr>
<td>3</td>
<td>Cartilaginea</td>
<td>3</td>
<td>15</td>
<td>16.50</td>
<td>11.50</td>
<td>9.50</td>
<td>0.45</td>
</tr>
<tr>
<td>4</td>
<td>Lissemys scuata</td>
<td>2</td>
<td>17.5</td>
<td>14.25</td>
<td>18</td>
<td>14</td>
<td>0.95</td>
</tr>
<tr>
<td>5</td>
<td>Cyclemys dentata</td>
<td>2</td>
<td>19</td>
<td>14</td>
<td>17.75</td>
<td>11</td>
<td>1.62</td>
</tr>
</tbody>
</table>

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CL = Carapace length  CW = Carapace width  PL = Plastron length  PW = Plastron width
Discussion

The present research started from June 2010 to November 2011. In the study period, 5 species of turtles and tortoises belonging to the 5 genera, 3 families under Testudinata were collected from Kalay environs.

During the study period, families Testudinidae, Trinonychidae and Bataguridae were recorded. Five species are Indotestudo elongata, Manouria emys, Amyda, cartilaginea, Lissemys scutata and Cyclemys dentate. Among then, Amyda cartilaginea and Lissemys scutata are endemic species of Myanmar. And then, Indotestudo elongate, and Manocria and Manouria emys are terrestrial, Amyda cartilaginea and Lissenys scutata are aquatic and Cyclemys dentate is semi aquatic (Table 1)

All species were found from Kalaymyo, Kangyi, Myittar River, Htoma and Sakhongyi respectively.

Altogether 24 species were collected from Kalay environs. Then, Manouria emys is largest and only one recorded.

In that regard it is interesting to note the survey results at the upper Chindwin River. All informants claimed that, ten years ago, turtles still were umuch more plentiful than they are now. However, it seems that the organized turtle trade for the Chinese market only reached the upper Chindwin area 2-8 years ago, probably because turtles become more and more depleted in area closer to Mandalay, the reputed trade centre for the export to China. Thus, it seems that this massive pressure on the turtles at upper Chindwin (Monywa) surveyed by Platt et.al (submitted) already seems to make lost the majority of turtle species (Kuchling, 2002).

Now, turtle’s population is declining all over the world including Myanmar. For their conservation, we must distribute the knowledges of chelonians to people and provent by law exactly. Hence, more researchs are necessary to know the distribution and conservation of turtles and tortoises in Kalay environs.
Acknowledgements

I acknowledge U Myint Swe (Acting -rector) and Dr. Ye Htut, Pro-rector of Kalay University, for their permission to conduct this work.

I would like to express our heartfelt t thank for Dr. Kyi Kyi Soe (Professor and head), Department of Zoology, Kalay University, for her suggestions, comments and constant encouragement throughout our research work.

I also thank for Dr. San San Win, Lecture Department of Zoology, University of Monywa, for help given in various ways.

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